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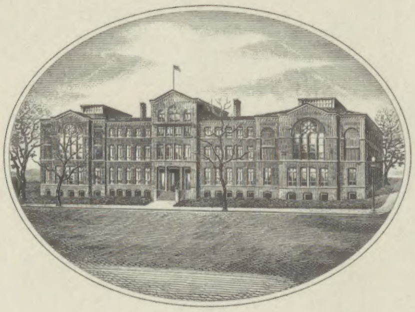

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for

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ADDENDUM ON PROTEINS IN PRACTICAL NUTRITION

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Much progress has been made and is being made in our understanding of the role of proteins in the nutrition of animals. It will be discussed under two headings.

1. Protein quality or the biological value of proteins.
2. Digestibility of proteins and the availability of the amino acids of digested proteins.

Protein quality (biological value). Proteins are said to be of good quality or high biological value if they meet the protein needs of omnivorous and carnivorous animals when they are fed in reasonable amounts. Proteins from animal sources such as muscle meat, most organs, milk, eggs and fish are proteins of high quality. They are proteins of high quality because they contain the amino acids the animals require for their growth and metabolism and these amino acids are readily available.

Not all proteins from animal sources are high quality. Gelàtin, which is derived from connective tissue, is of low quality, because it is deficient in several essential amino acids. Some proteins, as those present in hair and hoofs, are of low quality because they are indigestible.

Cereal proteins are of lower quality than proteins from animal sources. One reason, perhaps, the chief reason, is to be found in the character of their amino acid make-up. They seem to be deficient in adequate amounts of one or more essential amino acids. The cereal proteins differ among themselves in quality. Corn proteins are poorer quality than wheat proteins. The quality of protein in the same cereal varies with the portion of the cereal from which it comes. The outer coating of wheat consisting of the bran and middlings has a higher quality of proteins than the white flour.

Since the cereal proteins form such a large part of the protein intake of animals, numerous attempts have been made over many years to improve the quality or biological value of the cereal proteins by supplementing them with proteins from other sources. Effective supplementary proteins for the cereal proteins have been found in proteins from animal sources, such as milk, meat, eggs and fish. These proteins when fed with the cereal proteins raise the biological value of the cereal proteins. Thus proteins of high quality (animal proteins) when they are mixed with proteins of lower quality (cereal Proteins) result in a protein mixture, not of intermediate quality as one might expect, but of high quality. Such a protein combination which improves the quality, is known as protein supplementation. It is an important biological fact that the cereal proteins which are of mediocre quality can be changed to proteins of high quality by sup-

plementation with proper animal proteins.

In the present emergency, there is rapidly developing a shortage of animal proteins. Moreover, meats, eggs, fish, and milk are rapidly increasing in cost. As a result, much interest has been aroused in supplementing cereal proteins from other than animal sources. One legume - the soybean, supplements the cereal proteins quite effectively; i.e. to a greater extent than any other known proteins of vegetable origin. By supplementing the cereal proteins with the soybean proteins, the intake of animal proteins can be reduced without endangering the quality of the total protein intake.

Little is known about the nut proteins or the proteins of the leafy vegetables and tubers which form such a large part of our diet. Aside from the apparent inability of these proteins to supplement the cereal proteins, little is known about them. There is, however, some evidence that nuts such as walnuts and almonds contain proteins of high biological value.

In the present stage of knowledge it seems desirable that some animal proteins should form part of the diet of carnivorous and omnivorous animals including man to insure that the total protein intake will be of the highest quality. It remains to be seen whether by proper combinations of vegetable foods it will be possible to supply a protein mixture of high quality without the inclusion of any animal proteins. Perhaps vegetable proteins are too deficient in one or two essential amino acids. If it were known with certainty the exact amino acids which are missing they might be supplied with synthetic amino acids made in the laboratory. If this were possible, proteins of high quality could then be fed without the need of incorporating animal proteins. Such a possibility is at present in the realm of speculation.

Proteins of high quality need not be fed to herbivorous animals, more especially the ruminants, since in their spacious gastro-intestinal tract there grow micro-organisms with high synthetic powers. These micro-organisms synthesize from many nitrogenous compounds the amino acids including the essential amino acids that they need for the proteins of their cells. The proteins of the cells are in turn digested and the amino acids utilized by the animal, thus freeing the herbivorous animal from the necessity of ingesting proteins of high quality.

Digestibility and Availability. -Before a protein can be utilized by an animal, it must be digested by the enzymes in the digestive juices of the animal. No matter how excellent is the amino acid composition of a protein, it is of poor quality if it cannot be digested. Many naturally-occuring proteins such as are found in horns hoofs, and hair, or wool are of little value because they cannot be digested. Much work has been expended in attempts to make them digestible. Some of these proteins have been rendered more susceptible to digestion by chemical treatment such as solution in sulfide liquors. These studies have not yet progressed to the point where they might be of practical value.

Other naturally-occuring proteins, while easily digestible contain some of their essential amino acids in such combination as to render them unavailable to the animal. Little is known of such types of chemical structures. The best example is the proteins of the soybean. Methionine and, perhaps, cystine are unavailable when the raw soybean is fed, even though the proteins seem to be digested. The amino acids can be made available by heating the soybean, and the soybeans must be heated if their proteins are to be of high biological value. The heat seems to break up those unknown complexes and after proper heating the methionine and cystine are available.

While heating will improve the protein quality of the soybean, and perhaps other proteins, too much heat will decrease the biological value of many proteins. To get the highest quality of proteins from the soybean it must be heated very carefully, and the exact amount of heating necessary has been accurately worked out by the commercial houses selling the soybeans. Thus, the heating necessary to cook food (moist heat) may improve the biological value of some proteins and reduce that of others. It is important in any case to use only the amount of heat necessary to cook the food properly. Overcooking not only wastes power, but may reduce the protein quality of foods, even those which are improved by heating in the proper degree.

Dry heating is especially destructive to foods, reducing the quality of the proteins by rendering them indigestible by the enzymes of the digestive tract. Toasting bread may cause a sharp reduction in the protein quality of the bread.

When proteins are hydrolysed with enzymes or acids, "predigested" proteins are obtained. This predigestion will not improve the quality of these proteins but more likely will reduce it. Attempts to "help" the body along by such processes as predigestion of the proteins often has an unexpected deleterious effect.

THE PLACE OF THE MINERAL ELEMENTS IN ADEQUATE HUMAN NUTRITION 4.

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Certain of the mineral elements found in nature are essential for the maintenance of the life and well being of the animal organism. These elements may be classified into three groups according to their chief functions. Such a classification is not rigid since there is a great deal of overlapping of function. The classification of the groups and the members of each are:

I. Mineral elements chiefly concerned with the maintenance of the skeletal system. Calcium, magnesium, Fluoride and Phosphate ions.

II. Mineral elements chiefly concerned with os motic and neutrality regulation. Sodium, Potassium and Chloride Ions.

III. Mineral elements chiefly concerned with biocatalysis. Iron, Copper, Zinc, Manganese, Cobalt and Iodine.

Each of the above ions is a dietary essential and a deficiency of any one of them leads to characteristic physiological disturbance and disease conditions. In many instances we have only an imperfect knowledge of the train of events which follow upon deprivation of the mineral elements under varying circumstances.

Most interesting is the fact that the mineral elements carry on their physiological functions in unison with the vitamins and the ductless glands of the body. This is illustrated by the relationship between the adrenal cortex and sodium and potassium, vitamin D and calcium and phosphorus, the parathyroid glands and calcium, the thyroid and iodine.

The estimated daily requirements of most of the mineral elements for different age groups are shown in Table I. (See page 2)

Part I

MINERAL ELEMENTS OF THE SKELETAL SYSTEM

Calcium has been assigned a role in almost every metabolic process in the animal body and has been mentioned as an important causative factor in many organic and functional diseases. This element has assumed paramount importance among the inorganic elements in the study of nutrition, and it has been more extensively investigated than any of the other mineral substances. The metabolism of calcium is directly connected with vitamin D and parathyroid gland function. Vitamin C and the sex hormones seemingly have an indirect influence on skeletal development and ossification.

Calcium is present in the body to a far greater extent than any of the other basic mineral elements. A new born baby contains about 24 gm. Ca, and an adult of 70 kg. about 1200 gm.

Table I

Approximate Quantities of Mineral Elements
Required per Person per Day
U. S. Food and Drug Administration

	Infants 20 lbs.	Children 50-100 lbs.	Adults 150 lbs.
Salt (Sodium Chloride)	---	1.65 g.	10.0 g.
Potassium	---	1.50 g.	3.0 g.
Calcium	1.0 g.	1.0-1.4 g.	0.8 g.
Phosphorus	0.7 g.	1.0 g.	1.0 g.
Magnesium	0.15 g.	0.25 g.	0.35 g.
Iron	7.0 mg.	15.0 mg.	12.0 mg.
Iodine	0.1 mg.	0.1 mg.	0.1 mg.
Copper	1.5 mg.	2.0 mg.	2.0 mg.
Manganese	2.5 mg.	3.0 mg.	1.5 mg.

During pregnancy and lactation the requirements are increased to: calcium 1.5-2.0 g., Phosphorus 1.5 g., and iron 15 mg.

(nearly 3 lbs.) in the whole body. Of this quantity, 99 per cent is in the skeleton.

The need for calcium by the animal is large and calcium deficiency is always a potential factor in the diet of man, particularly in the American dietary. The optimum requirement for different ages is shown in Table I. For growing children a good level is about 1 gm. per day. Women during late pregnancy and lactation show an increased need for calcium to amounts between 1.5 and 2.0 g. per day.

<u>Dietary Sources of Calcium</u>.- For extensive information on the calcium content of different foodstuffs, one should consult tables giving analysis of food stuffs. These tables usually give the analyzed content of phosphorus, iron and copper also. Such tables are to be found in any of the many standard texts on nutrition. Firms like The Prudential Insurance Co. and H. J. Heinz Co. have prepared brochures containing tables of food analysis.

The best source of calcium is in milk and milk products; cheese, ice cream, custards. Other good sources are egg yolk, sardines, salmon, shellfish, and beans and other legumes. Outstanding in calcium content among the vegetables are broccoli, cauliflower and kale. The cereal grains are generally a poor source of calcium. However, white bread is a fair source and soy bean flour an excellent source of calcium. Considerable discussion has been underway on the desireability of fortifying white flour with calcium as well as with iron, thiamin and nicotinic acid.

In many of the leafy vegetables, because of the presence of oxalic acid the calcium is not in an available form and if there

is an excess of oxalic acid, calcium is robbed from other sources. For example, the calcium of spinach and rhubarb is poorly utilized, that from kale is well utilized.

Wherever possible, calcium should be supplied in the form of milk products because of other valuable nutritive factors in milk.

Use of Calcium Salts.- During pregnancy and lactation, in the case of individuals allergic to milk products, and in certain bodily disorders it may be desireable or necessary to supply calcium in the form of its salts. Calcium salts that may be used for this purpose are calcium carbonate (precipitated chalk), dicalcium phosphate, calcium glycerophosphate, calcium lactate and calcium gluconate. Calcium carbonate is probably best suited for fortification of foods. Dicalcium phosphate is usually prescribed to make up the extra calcium and phosphorus in high mineral diets. Calcium lactate and gluconate, being soluble, are suitable for injection and are used for emergency purposes, such as in the treatment of tetany and bleeding.

In the great majority of cases, the prescription and administration of the salts of calcium come within the province and duties of the medical profession.

Phosphorus and Magnesium.- This element comes next to calcium in num erical importance. About 80 per cent of the phosphorus is in the skeleton where it is combined with calcium to form the mineral portion of the bone. The largest store of magnesium is also in the bone. About 0.6 to 1.0 per cent of bone ash is magnesium. The functioning of these three mineral elements are closely interrelated.

Phosphorus is also largely distributed in the soft tissues and cells of the body where it occurs in many organic compounds, e.g., phospholipids, nucleic acid, phosphocreatine, phosphorylated sugars, etc. Magnesium also is an important constituent of the soft tissues and organs of the body.

Abundant amounts of phosphorus and magnesium are present in food from both animal and plant sources used by man, so that it does not seem likely that a dietary deficiency of these minerals occur in man under ordinary circumstances. However, phosphorus deficiency may occur in man. The disease of infancy - rickets - is chiefly a disease of phosphorus deficiency, due to the inability of the organism to utilize phosphorus and calcium in the absence of vitamin D. Cereals tend to aggravate and intensify rickets. The reason for this is that while cereals are rich in phosphorus, it is present to a large extent in the compound phytin, from which the phosphorus is difficult to set free. Many of the diets even in the United States which are excessive in sweets (e.g., the Southern diet of hominy grits, syrup and fat pork) are deficient in phosphorus as well as other things. Children who are allowed to fill up on sweets to the neglect of more substantial foods doubtless are receiving insufficient phosphorus too. The dietary requirements of phosphorus is shown in Table I.

In grazing cattle, deficiency of phosphorus is a common occurance in many parts of the world under acid conditions where the forage becomes dry and depleted of phosphorus. The difficulty may be due to a deficiency of phosphorus in the soil. Crops grown on phosphorus-poor soils show a lowered phosphorus content and also a decrease in the yield. Aphosphorosis is a serious problem in many parts of the world. In the United States it has definitely been recognized in Montana, Minnesota, Wisconsin, Michigan, Kansas, Utah, Texas, Florida, and California.

Calcium to Phosphorus Ratio.- Not only is it necessary that the diet contain adequate amounts of calcium and phosphorus, it is also important that these constituents are maintained in a proper proportion to each other. Excessive amounts of calcium will prevent the proper utilization of the dietary calcium and conversely excessive phosphorus will prevent utilization of the calcium. To produce rickets in rodents, it is necessary to have an excessive calcium : phosphorus ratio in the diet as well as a deficiency of vitamin D.

Suitable ratios range anywhere from approximately one part calcium to 1.5 parts phosphorus up to 2 parts calcium to 1 part phosphorus. It is important to bear in mind that a correct calcium to phosphorus ratio does not make up for the quantitative lack of these elements.

Magnesium Requirements.- Recent studies by Tibbets and Aub have shown that sedentary adult subjects may get along on about 0.2 grams of magnesium per day, more active subjects on about 0.3 grams per day. Children 4 to 7 years of age were found to have a magnesium requirement of about 13 mg. per kilogram of body weight. The values given in Table I are probably a safe estimate of magnesium requirements.

PHYSIOLOGICAL FUNCTIONS

Calcium primarily is required for the building and maintenance of sound bones and teeth. Lack of calcium leads to a weakening and brittleness of bone which is scientifically known as osteoporosis. Nutrition authorities have a strong suspicion that the osteoporosis which is common in elderly people is probably due to insufficient intake of calcium. In the development of healthy bone and teeth, vitamin C, vitamin A, and most important vitamin D, function in conjunction with calcium and phosphorus.

Vitamin C is required for the normal development of the connective tissue matrix and the system of fine blood vessels in the bone. Vitamin A keeps the bone destroying cells, osteoclasts, in bound and vitamin D is required for normal mineralization of the bone. In infants, vitamin D lack leads to rickets, in adults to the disease osteomalacia.

Calcium has numerous other functions besides that of skeletal development. Some calcium is required for the coagulation of the blood. Without calcium the higher animals would face the

constant possibility of bleeding to death.

Calcium is required to maintain the tone of the muscles and to keep the heart beating. Administration of calcium salts has been found to be an effective way of treating colic.

When an experimental animal like the rat is reared on a calcium-low diet, it shows the following changes:

1. There is a loss of appetite and retarded growth.
2. The basal metabolic rate is increased.
3. Due to improper skeletal development and greatly demineralized bones, there is an abnormal gait and posture.
4. Internal hemorrhages in different parts of the body, particularly the brain and intestinal tract are frequent.
5. There are frequent bouts of prostration associated with a paralysis of the hindquarters.

The thyroid and parathyroid glands also have a part in proper calcium functioning. Deficiency of the parathyroid hormone causes the condition of tetany. In this condition there is a heightened initability of nerve and muscle which often ends in attacks of bodily convulsions. Excess secretion of the parathyroid hormone causes demineralization of bone, which leads to frequent fractures upon slight provocation.

Phosphorus has numerous other important physiological functions besides forming part of the mineral matter of bone. Rats on a phosphorus deficient diet live only about 10 weeks. The skeleton becomes extremely rarefied and this is accompanied by a progressive disability in walking, standing and breathing.

Many of the biologically important compounds are derivations of phosphorus. Examples are the phospholipids, nucleoproteins, phosphorylated sugars and sugar derivatives and phosphocreatinine. Phosphorus is important for muscle activity, nerve transmission, absorption and transport of fats and sugars, the burning of fats and sugars in the body and in the excretion of certain waste materials.

Magnesium is present to the extent of only about one per cent in bone ash, but this amount appears to be necessary to give a bone normal strength. Deficiency of magnesium leads to very dramatic consequences. The first effect is a dilatation of the surface blood vessels. This causes the animal to assume a rosy to purplish appearance. This is followed by an increased initability of the nervous system which causes general convulsive attacks from time to time. This is known as magnesium tetany.

At a still later period there is a massive accumulation of calcium in the soft tissues and organs of the body. The calcification is most pronounced in the kidneys and is there associated

with failing kidney function. The damage to the kidneys causes a loss of protein in the urine and a decrease in the plasma proteins which eventually leads to the development of an edema.

Large doses of magnesium acts as an analgesic and anaesthetic. Animals have been operated on under magnesium anaesthesia. Magnesium reduces blood pressure. It has been used successfully in the treatment of certain types of high blood pressure. This has been most successful in the toxic condition of pregnancy known as eclampsia. Administration of magnesium salts lowers the blood pressure and eases the distressing sysptoms of eclampsia.

The discussion given above represents only a small portion of the physiological importance that has been discovered for the activities of calsium, magnesium and phosphorus in the animal organism. It can be readily understood how it is that a malnutrition of these important minerals leads to a variety of bodily ills.

PART II

MINERAL ELEMENTS CONCERNED WITH OSMOTIC AND NEUTRALITY REGULATIONS

Animal tissues contain considerable amounts of sodium, potassium and chloride. The usual plant tissues are rich in potassium but low in sodium and chloride. Man on an omniverous diet, and the carniverous animals, obtain a sufficient supply of all three of the above elements from their food to m et their physiological needs. However, most of us prize the taste of more highly salted food than is met with in nature. Although we probably would not suffer in health, few of us would be willing to forego the flavor in food shich is supplied by the addition of table salt.

The Herbivora do not always obtain a sufficient supply of sodium and chloride from their forage. Wild herbiverous animals (deer, buffalo) travel long distances in search of rock salt deposits, or salt licks to remedy this deficiency. Asside from a somewhat unthrifty appearance, cattle and sheep show little effect of the deprivation of salt except during gestation and lactation. The salt deprived animals have a lowered fertility. Dairy cows that do not have access to table salt are very apt to have a breakdown in health at the time of calving. The breakdown in health is marked by a loss of appetite, a generally haggard appearance, lusterless eyes, a rough coat, and a very rapid decline in both weight and yield of milk.

Supplying crude salt to cattle and the use of table salt by man is probably the most ancient and certainly is the most widespread example of food fortification.

<u>Requirement</u>. The requirement of sodium chloride and of potassium is shown in Table I. The value of 10 grams of sodium chloride for an adult as shown in the table represents the usual intake rather than an actual requirement which could be met by a much lower quantity. Milk, cheese, meat, whole grains, and sea

foods are good sources of these three mineral elements. A mixed diet can hardly fail to contain adequate amounts of the three.

Deficiency Symptoms.- Experiments with small animals have shown that a severe deficiency of either sodium or potassium causes a retardation of growth, decrease of appetite and increased mortality rate.

A characteristic effect of sodium deprivation observed by Orent-Kieles and McCollum, was the development of eye lesions, due to ulceration and keratinization of the epithelial structures of the eye. There was no diminution in the secretion of tears in contrast to the effect of vitamin A deficiency. The same authors observed a fragility of the bones and an upset in the sex cycle of the female.

McCance found that sodium chloride deficiency in man, in which 25 to 30 percent of the body stores was depleted by a low intake and sweating, produced aberrations of food flavor, a peculiar sensation in the mouth that was not thirst, cramps, weakness, lassitude and severe cardio-respiratory distress (rapid heart rate and shortness of breath) on exertion. There was deterioration of mental activity to perform tasks requiring keen mental judgement.

Characteristic effects of potassium deficiency are a slowing and irregularity of the heart and poor development of the voluntary musculature. Potassium lack produces a predisposition toward intestinal stasis (constipation). Chloride deprivation has not been observed to produce any characteristic symptoms.

In normal health, extreme variations in the intake of these three mineral elements can be tolerated. The control is maintained by shifts in the excretory function of the kidney. On high intakes, the excess is rapidly eliminated, on low intakes the excretion drops nearly to zero. The response of the kidneys to the amount of potassium, sodium or chloride that is ingested is very rapid and extremely delicate. In the course of a few hours the content of these ion compounds in the urine can change from a very large amount to merely a trace, in rhythym with the changing conditions of excess or of scarcity in the body.

In certain diseases the sodium and potassium intake has to be carefully controlled. The adrenal cortex is intimately connected with the metabolism of the above elements. Among the fundamental defects of Addison's disease (adrenal cortical deficiency) is an excessive excretion of sodium and excessive retention of potassium. An interesting disease known as Familial paralysis, characterized by abrupt attacks of flaccid paralysis, without sensory loss or psychic disturbances, can be relieved by the administration of potassium salts. Onset of attacks is characterized by a reduction in the serum potassium. The potassium intake has to be controlled and should be kept low in severe Bright's disease. Addis has shown that the toxicity produced by feeding liberal amounts of meat in this condition is due to the fairly high potas-

sium content of meat. Potassium is not readily eliminated by the damaged kidney and its excessive accumulation affects the heart.

Osmotic Control and Water Balance. The proper concentration of the salts and the water content of the body is factor of great importance for proper bodily health. Sodium and chloride and potassium have contrasting roles in this function. The body consists of cells bathed by a watery fluid. This fluid has about the same composition as is found in blood plasma and lymph. The water outside of the cellular constituents of the body (extracellular water) represents about 20 per cent of the total body water. The rest of the water is intracellular. There is a barrier to the free exchange of ions between the outside and inside of the cells. The extracellular water makes up the internal environment of the higher animals.

Sodium and chloride are present practically only in the extracellular fluid, potassium is preponderantly present dissolved in the intracellular water. This difference in distribution determines the characteristic role of each of the ions in water balance.

In emaciation, or in voluntary fasting, there is a loss of body protein and breakdown of body cells. This occasions a depletion of intracellular water and a discharge of potassium which is recognized by an excessive excretion of potassium in the urine whenever there is wasting of the body.

Sodium and chloride parallels the changes in extracellular fluid. Excessive loss of sodium chloride follows upon profuse perspiration in a hot climate particularly when one is engaged in heavy work. As is widely known now, drinking water without salt to balance it leads to the effects of water intoxication, which has been named "miners cramps", or "stokers disease" or "heat stroke". The remedy is simple, to take some table salt along with the water. Many cases of heat stroke were either averted or quickly treated by this procedure during the building of Boulder Dam.

When an excessive amount of sodium chloride accumulates in the body, because of a very high intake or because of poor kidney action, water has to be retained to balance this. The water accumulation is seen by the appearance of edema under the eyes or at the ankles.

Acid-Base Regulation. The elements, sodium, potassium, and chloride have important functions in connection with the acid-base balance and buffering of the blood and body fluids. Normal health requires that the blood be constantly maintained at a very slightly alkaline reaction. This is expressed by a symbol, the pH, which has the correct value at 7.4.

Excessive accumulation of acid products leads to a condition of acidosis, accumulation of alkaline products to a condition of alkalosis. The exact balance is maintained by the buffer substances of the body. The chief source of the alkali for buffer-

ing is supplied by sodium and potassium. These are balanced by the acid radicals of chloride, bicarbonate and phosphate. In the majority of instances a condition of acidosis or alkalosis is primarily due to some deepseated bodily disturbance such as diabetes or Bright's disease rather than being the fault of the diet. In normal health adjustments to the proper acid-balance is readily made by the body regardless of the kind of food eaten. In disease conditions, food has an important role as a corrective treatment to keep the regulation of the acid-base balance of the body within its impaired capacity.

Foods like the cereals and meat products have a preponderance of acid-forming radicals in their makeup, like sulfur and phosphate. These are converted to the corresponding acids by the metabolic processes of the body. Thus, they are acid forming foods. Foods like the fruits and vegetables, even though they may be strongly acid tasting, contain large amounts of the potassium and sodium salts of organic acids like citric and malic acid (e.g., citrus fruits, apples, pears). These organic acids in the animal body are metabolized to bicarbonate, thus forming potassium and sodium bicarbonate which are basic salts. Sodium bicarbonate is common baking soda. Consequently the fruits and vegetables are potential base forming foods. The correct balance, which is what is desireable, can be maintained by a proper selection from both the acid and base forming foods.

Food balance by a wide selection of different kinds of food, is the best means of maintaining optimum nutrition. Any teaching contrary to this is based on fraud and quackery.

PART III

MINERAL ELEMENTS CHIEFLY CONCERNED WITH BIOCATALYSIS.

(See Proceedings of the Defense Nutrition Institute held at the University of California, Berkeley, June 30 to July 12, 1941; Minerals, are the Trace Elements important in Nutrition, by David M. Greenberg, p. 30)

LATE DEVELOPMENTS IN VITAMIN D

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This is merely a listing of the newer facts and problems which have arisen in the last four or five years concerning the uses of vitamin D.

I. FORMS OF THE VITAMIN

For all practical purposes there are only two forms of vitamin D, called D_2 and D_3 respectively. Vitamin D_3 is activated or irradiated 7 dehydrocholesterol, an animal sterol. This is the chief form found in fish liver oils and in irradiated milk. It is readily absorbable. Vitamin D_2 is the activated form of ergosterol and is the original product uncovered by Windaus in 1926. Ergosterol is a vegetable product and is largely unabsorbable by the animal intestine, In the irradiated (with ultra violet rays) form it is absorbable, but is of varying potency in the different species. In fowls, for example, at least 100 times the amount required as D_3 must be supplied as D_2 to provide protection against rickets. In rats, dogs and probably in man, the two forms of D are apparently equivalent in antirickettic value, although the evidence indicates some advantage to D_3.

Reference: McCollum, Orent, Keiles & Day. Newer Knowledge of Nutrition, 1939, Chap. 14

II. INTERRELATIONSHIP BETWEEN VITAMINS D AND A

In the earlier work on the D requirement fish liver oils or concentrates were used and their accompanying vitamin A largely ignored. There is now available evidence that large dosages of vitamin A may exert a protective effect against the possible toxic properties of excess vitamin D. This protection may be effected by favorable conditioning of tissues, particularly the epithelial tissues, against abnormal deposition of calcium salts. When large doses of D are to be used it would seem wise, therefore, to incorporate with them a corresponding amount of A.

Reference: Morgan, Shimotori & Hendricks: J. biol. chem., vol 134, p 761, 1940

III. THE VITAMIN D REQUIREMENT

There is little doubt that many infants and children require some vitamin D by mouth, particularly in winter, in foggy or excessively hot districts. This is true particularly of premature or unusually large and rapidly growing children. Many other conditions may come into play, but the chief limiting factor is the amount of direct ultra violet irradiation from sunshine, sky shine or artificial source which the child receives

on the exposed skin. Obviously, also, a diet deficient in calcium or phosphorus can not be made adequate by addition of vitamin D only. However, the diet of the infant or child receiving from one pint to one quart of cow's milk daily will not be lacking in these elements.

A controversy has gone on among pediatricians for some years as to the optimum daily amount of vitamin D for prevention of rickets and promotion of bone growth in infants and children. Jeans & Stearns have summarized the findings adequately. Their own experience indicated that normal health and growth in length of infants was obtained on 135 U. S. P. units of vitamin D daily. Somewhat better linear growth and less variability in calcium retention resulted when 300 to 400 units were given daily. But when 1200 to 1800 or more units were given daily definite decline in rate of growth resulted. The maximal influence of vitamin D may be assumed to be exerted at from 300 to 600 units daily and adverse effects to begin above this level, definitely asserting itself at 1800 units.

No such definite conclusions are available as to the need of older children for vitamin D. Most of the studies on children have been concerned with the incidence of dental caries. Both positive and negative results have been reported for dosages of 350 to 900 units daily. Neither complete cures nor prevention of tooth decay have been obtained by the use of vitamin D. Some slowing of progress of the disease has often been obtained, but obviously other nutritional or other factors are involved also in the caries condition.

In adult subjects the vitamin D requirement has been investigated chiefly with reference to calcium retention or balance. No positive relation has been established.

In late pregnancy large calcium retention is necessary and there is some evidence that vitamin D assists in bringing this about advantageously. The same statement applies to lactation. No certain advice can be given as to the quantity, however, since this may depend upon the calcium and other contents of the diet, upon the stage of pregnancy, the amount and kind of sun exposure available, the efficiency of digestion and probably other factors. Certainly no intake larger than 400 units of vitamin D daily is likely to be needed or even safe.

References: Jeans & Stearns, J.A.M.A. 111 703, 1938
(The Vitamins, Am.Med.Assoc., 1939,Chap.26)
Day & Sedwick, J. Nutrition, 8, 309, 1934
McBeath & Zucker, J. Nutrition, 15, 547,1938

IV. THE DANGER OF EXCESS D INTAKE

It has been clearly shown that vitamin D is toxic to rats, dogs and human beings and that the level at which such toxicity asserts itself varies with the species, age, type of vitamin,

calcium and phosphorus content of the diet, sun exposure, amount of accompanying vitamin A and probably other factors. The vitamin is stored in the tissues and the toxic dose may therefore be accumulated from long-continued small daily intake. The more delicate the criteria used for detection of these effects the lower has been placed the level at which damage may occur. In dogs such effects have been found to be severe jaw and teeth disease, calcification of many soft tissues, particularly the kidneys, lungs, heart, stomach and blood vessels, decalcification of the bones. Some but not all of these changes are reversible.

References: Shohl, A.T., Mineral Metabolism, 1939
Reed, C.I., Struck, H.C. & Steck, J.E., Vitamin D. Univ. of Chicago Press, 1939

V. MASSIVE DOSAGE OF VITAMIN D FOR RICKETS PREVENTION

Since 1937 certain German pediatricians have advised the administration of one large dose, about 200,000 units of a concentrated vitamin D preparation, to infants instead of daily giving of small doses. This practice is now being tried in the United States. It has certain obvious advantages as a public health measure but should be carefully examined before being accepted as without danger.

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VI. SOURCES OF VITAMIN D NOW AVAILABLE

Viosterol preparations are made from irradiated ergosterol (D_2) and may be of very large potency. It carries no vitamin A. Cod liver oil is mild in its vitamin D activity (about 100 units per gram) and always carries some vitamin A as well. One teaspoonful per day is optimum for infants. Many other more potent fish liver oils are now used in addition to, and in fact, instead of, cod liver oil. Each of them is labelled as to vitamin D and A value per gram.

Irradiated milk, both fresh and evaporated, is another mild source of vitamin D for infants. The amounts provided by the usual milk ration of an infant varies from 90 to 400 units daily. This is D_3. Other fresh milk, fortified with an extract of fish liver oils, is available on some markets.

VII. SUMMARY

Infants need from none to 400 units of vitamin D daily and suffer from an excess. Children may need a similar amount and their teeth may be maintained better for having some. Pregnant and lactating women may benefit from a similar intake but only in case good sunlight is not available and if proper calcium and phosphorus of the diet is assumed. Other adults may be harmed rather than benefitted by constant vitamin D intake, no matter how small.

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(For background and details of recent work consult the references. These have been selected first for availability, second for reliability.)

Importance of Various Sources

1. Palatability, quantity of food product usually eaten, relative range in vitamin C content in food as purchased, content of vitamin C as prepared for table use, and stability of vitamin C in prepared food product must be considered inevaluating the relative importance of the particular food as source of C. The relatively high content of C in citrus fruit, their availability, the nutritionally insignificant variation in C content with variety, maturity and growing conditions, stability of C in citrus juices, combine to make these a standard and reliable source of vitamin C. Other foods may contain much more vitamin C, for example, animal adrenals, peppers and guavas, but are not as important sources of C because of lack in palatability, small quantity used or limited availability.

2. Range in concentration of vitamin C in foods is wide. Meats are only a fair source of vitamin C although they retain their vitamin C content well during cooking. Adrenals are rich in ascorbic acid, 100-150 mg. per 100 gm.; livers vary from 20-40 mg.; brains are rather low 12-18 mg. and muscular tissue in most instances is devoid of vitamin C. Milk is relatively poor in vitamin C content, about 10-13 mg. ascorbic acid per quart or 2 mg. per 100 gm. but in the large quantities in which it is consumed it forms an important source of ascorbic acid, particularly for infants. Fruits vary from guavas that have been reported to contain as high as 300 mg. of ascorbic acid per 100 gm. (usually 150-200), to lemon (56), orange (54), grapefruit (39), strawberries (40-100), raspberries (13-30), tomatoes (23), apples 7-20), and plums, pears, peaches about 7-10. Vegetables vary from raw cabbage with average content about (35), raw peas (22), lettuce (13), celery (7) and carrots (4).

3. Vitamin C occurs in fruit and vegetalbe tissues as the reduced ascorbic acid and as the non-reduced dehydro-ascorbic acid its first reversibly oxidized product. The ratio of the two varies with kind of fruit or vegetable, its maturity, variety, and conditions of harvesting and treatment. Although dehydroascorbic acid is equivalent in biological potency to ascorbic acid it is more readily destroyed by heat and by oxidation.

4. Variety, freshness and maturity affect the vitamin C content of fruits and vegetables but in different degrees. The percentage of vitamin C in tomatoes increases as they ripen, that in peas decreases. Apples increase slightly in total ascorbic acid content while oranges and other citrus fruits decrease. The

total ascorbic acid per orange, however, increases with maturity since the volume of juice per orange increases.

5. The vitamin C content of vegetables (particularly snap beans, peas and spinach) decreases rapidly during storage at room temperature. Bruising the tissues markedly increases rate of loss of vitamin C. Refrigeration, however, greatly reduces this loss.

6. The vitamin C content of citrus fruits does not decrease significantly during cold storage; that of apples does. Fruit tissue that is discolored as a result of mechanical injury, sub-oxidation during storage, or by some other physiological cause (soft scab in Jonathan apples, internal browning of Newtown Pippins or Bartlett pears) is low in C content. Use only sound fruit.

7. Commercially canned acid fruit products retain their vitamin C well; retention in glass is likely to be poorer and loss increases with the amount of air present. Frozen fruit even when packed in sugar or syrup suffers loss in C during storage. Here too the degree of discoloration or browning is an indication of vitamin C loss. Only vegetables scalded before freezing retain C during storage. Dried fruit must be sulfured for C retention. (See report of W. V. Cruess in Proceedings).

8. Data on vitamin C content of acid fruit products stored in tin cans (particularly open cans) when obtained by the usual indophenol titration is erroneous because of interference of ferrous ions. Do not trust it.

<u>Destruction of ascorbic acid</u>

1. Ascorbic acid is relatively heat stable in the absence of oxygen and in acid solution but its reversibly oxidized form, dehydroascorbic acid is markedly less stable.

2. Chief source of loss in ascorbic acid is by oxidation. This oxidation is catalyzed by

a. A more or less specific enzyme. Ascorbic acid oxidase is widely distributed in vegetables such as cabbage, carrots, cucumbers, stringbeans, lettuce, turnips, radishes and in tomatoes and certain other fruit.

b. Phenolases (Catecholase, Tyrosinase, Laccase occuring in fruits such as apples, bananas, pears, peaches, apricots and in potatoes) which in the presence of suitable phenols and oxygen induce oxidation of ascorbic acid.

c. Respiratory enzymes such as cytochrome oxidase and cytochrome.

d. Copper, iron, and manganese salts particularly when activated by proteins.

3. Enzyme catalyzed oxidation is so rapid that complete loss of vitamin C may occur when the tissue is completely crushed as in extraction of juice from apples, tomatoes or vegetables in the home.

4. Oxidative destruction of vitamin C is hastened by exposure of food, in finely chopped condition, to air and is retarded by prompt removal of oxygen in the tissues or by scalding to inactivate enzymes. Peeled fruits that brown on exposure to air (apples), when submerged in a dilute salt solution long enough to enable the respiratory process to use up all oxygen in them will retain their vitamin C content during subsequent processing. Browning or discoloration is always accompanied by loss in vitamin C.

5. The ascorbic acid content in citrus juices and in heated tomato juice is not lost as rapidly in the refrigerator as formerly assumed. The loss is less than 10% in 12-24 hours at 45°F in opened can.

6. The rate of oxidation of ascorbic acid in fruit and vegetable tissues is increased as the pH increases. Avoid cooking with soda!

Loss of ascorbic acid by solution

1. Vitamin C is water soluble and on cooking the vitamin C present in plant tissues is rapidly leached by water.

2. Rate of loss varies with type of product and with the relative quantity of water used in scalding or cooking. See Fenton and Tressler (1938).

3. Cooking as such destroys very little of the vitamin C in vegetables, from 5 to 15 per cent under the usual conditions but a large amount, 33 to 53 per cent is dissolved by the water. The solution of the vitamin in the cooking water is greatest during first few minutes of boiling.

Directions for maximal retention of C during preparation may be formulated as follows:

1. Destroy enzymes by scalding (in steam or small amount of water).

2. Avoid aeration or un-necessary exposure to air.

3. Avoid contamination of food with iron and copper (use stainless steel knives, aluminum or agate cooking ware, etc.)

4. Avoid excessive washing with water (particularly of cut foods) and use only a small quantity of water during cooking. Use cooking water in sauces, dressings, etc.

5. Prepare for table use shortly before meal time.

Vitamin C requirement

1. The particular physiological role of C is not yet completely known. It functions not only in regulating the elaboration of supporting tissue (cartilage, teeth and bone, walls of

capillaries, etc.) but in respiratory activity of specialized tissues. It apparently influences the utilization of other vitamins in some way.

2. Large excesses of vitamin C have been fed without causing any harm. Liberal use of vitamin C is desirable according to some authorities for "optimum" life.

3. Old and ailing individuals, and those with certain pathological symptoms require more vitamin C than healthy individuals. (See general references.)

Physiology of vitamin C

1. The role of vitamin C in metabolism and growth is not completely known; but vitamin C is known to occur in highest concentration in tissues characterized by a high metabolic activity and affects the physical state of intercellular material and growth and repair of bones and teeth, cartilage and white fibrous tissue.

2. Cases of mild deficiency (sub-clinical) of vitamin C are very common: restlessness and irritability in infants and chilfren and run down feeling in adults; bleeding of the gums, poor tooth structure, weakening in capillary resistance, hem orrhagic skin lesions (stomach ulcers), and decreased resistance to infections are other symptoms of vitamin deficiency. There is increasing evidence that sub-clinical cases of vitamin C deficiency are widespread even though acute deficiency characterized by scurvy (soreness and stiffness of joints, swelling and bleeding of the gums with loosening of teeth and hemorrhages under the skin) is rare.

3. Vitamin C requirements are arbitrarily set on the basis of measurement of the strength of blood capillaries, determination of vitamin C content of the urine (vitamin C excretion) in comparison with intake, and determination of vitamin C content of blood. The difficulty lies in determining the physiological minimum, first detectable sign of vitamin C deficiency on the basis of healthy rather than diseased individuals. It is not a question of preventing scurvy but of insuring good health. The physiological optimum, a state of health that could not be bettered by further addition of vitamin C is even more difficult to set since vitamin C is excreted in the urine even when not fed in obvious excess and since the concentration in the urine and in blood is determined by many at present incompletely known factors.

4. Vitamin C intake may be increased well above the level necessary to saturate all tissues of the body without ill effect since excess is excreted. It is better to have too much vitamin C than too little, particularly because of its beneficial effects other than in preventing scurvy. In case of vitamin C deficiency prolonged feeding is necessary to cure symptoms.

5. The National Research Council Committee (May 1941) recommends the following amounts of vitamin C daily:

a. Infants from birth to 9 month, minimum 30 mg of ascorbic acid equivalent to 4 tablespoons of orange juice.

b. Children 9 month to 6 years, 35 gradually increasing to 50 mg (5 to 8 tablespoons)

c. Adults and older children, minimum 75 mg, 2-3 fluid ounces of orange juice; optimum 100 mg (1 cupful or more of orange juice)

d. Pregnant and lactating women, at least 50 mg (1/2 cup of orange juice) over the minimum for other adults.

e. Old people, minimum 50 mg (1/2 cupful of orange juice)

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VITAMIN E

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In the laboratory vitamin E deficient animals are unique in that they reach an apparently healthy adulthood but entirely lack the power of reproduction. The discovery of the deficiency was accidental for the study was designed to test the effect of dietary influence on ovulation and the various steps in the physiology of reproduction. On supposedly complete dietaries, and with both growth and external appearance normal, rats would ovulate normally and breed, and yet not give birth to living young. The addition of the then known accessory food substances (good sources of vitamins A, B and D; rats do not require C) was without effect but the incorporation of natural foods, particularly lettuce or whole grain cereal, led to the restoration of fertility. The curative factor was found to be fat soluble and in the non-saponifiable fraction of the fat as were vitamins A and D. The incorporation of slightly rancid lard in the diet had led to the oxidative destruction of the vitamin E present in the components of the ration. In contrast to the female, the effects of vitamin E deficiency in the male rat are irreversible. Once degenerative changes in the germ cells of the testes are initiated, the process can neither be repaired nor arrested.

The unknown factor was added to the then identified accessory food substances (A, B, C and D) and was termed vitamin E-- the antisterility factor. Its function, however, is not associated entirely with reproduction. Degeneration or breakdown of the striated musculature occurs in a number of species. The suckling young of mother rats supplied with minimal amounts of vitamin E become markedly paralyzed at the end of the lactation period (21 days). These young, although in good general nutrition (as judged by weight) have a marked degeneration of practically the entire cross-striated musculature. Clinically, the onset of the paralysis may be sudden or gradual. The animals may die but in about one third of the cases recover spontaneously. Adult rats maintained for over a year on a diet low in vitamin E exhibit a paresis and incoordination that is progressive but less severe than in the sucklings. Vitamin E low rats have essentially the same life expectancy as do normal animals but after the first year of life they present a scrawny, denuded appearance. Growth ceases after about the fourth month. The vitamin E deprived rats are undersized but not markedly so. It should be recalled that in other vitamin deficiencies (except D) death ensues in a few weeks or months.

Some species of herbivors, particularly guinea pigs and rabbits, are almost ideal test animals for the production of experimental muscular dystrophy; even the addition of cod liver oil to a normal grain ration will result in the oxidative destruction of vitamin E and the clinical picture of dystrophy appears in a matter of a few weeks. The same has been shown for goats.

Guinea pigs given minimal amounts of vitamin E (sufficient

to protect against muscular dystrophy) resorb their young; thus it would appear that the amount of vitamin E necessary for the maintenance of fertility in the guinea pig is greater than for the preservation of a normal musculature.

Different species vary in their reaction to a vitamin E low diet. The female mouse resorbs her young as does the female rat; however, the male shows no impairment in reproduction as the result of vitamin E deficiency. Nutritional muscular dystrophy has been observed in rats, guinea pigs, rabbits, dogs, ducks and mice. Chicks maintained on a vitamin E low diet show marked cerebellun lesions while turkeys likewise treated show a degeneration of the gizzard muscle; in ducks the degeneration of the striated musculature resembles the picture in rats and herbivora.

The vitamin has been isolated and synthesized, the pure compound being known as alpha tocopherol. It has been effective in preventing all of the disorders ascribed to a vitamin E deficient state.

Vitamin E is widely distributed in natural food stuffs; the best sources are the whole grain cereals and lettuce. It is therefore unlikely that man needs a source of vitamin E other than that found in the average mixed diet. Some investigators have claimed that habitual abortion (a rarity) is due to a deficiency in vitamin E, but this has not been proved. The use of vitamin E in the treatment of certain neuromuscular disorders in man has been suggested but long time therapy has given discouraging negative results.

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THE COMPONENTS OF THE VITAMIN B COMPLEX

The term vitamin B complex can be understood only in the light of the history of its development. In 1915 McCollum and Davis (1) introduced the term "water soluble B" to represent a vitamin which was soluble in water and was needed for the growth of rats. McCollum and Kennedy (2) concluded that their water soluble B was identical with Eijkman's (3) antineuritic vitamin which was necessary to prevent convulsions or polyneuritis in chickens and pigeons. Vitamin B was thereafter used to designate both of these factors. Vitamin B was found chiefly in yeast and cereal grains, especially in the germ of rice and wheat and in the bran of those cereals. Vitamin B was also found in lesser amounts in other foodstuffs.

Vitamin B proved to be far more complicated than any of its investigators ever expected. The story of the unfolding of the complex nature of vitamin B is one of the most fascinating and amazing chapters in nutrition and biochemistry. Thus far, the following vitamins of the vitamin B complex have been isolated, identified and synthesized.

1. Thiamine (vitamin B_1, antineuritic vitamin)
2. Riboflavine (lactoflavin, vitamin G, vitamin B_2)
3. Nicotinic acid (pellagra-preventive factor)
4. Pyridoxine (vitamin B_6, rat antidermatitis vitamin, antiacrodynia factor)
5. Pantothenic acid (chick antidermatitis vitamin, part of filtrate factor)

All these proved to be organic chemical compounds hitherto unknown to organic chemists with the exception of nicotinic acid which was first prepared in 1867. It has since been sitting on the chemist's shelf while countless thousands of people have suffered and died of pellegra for want of nicotinic acid until 1937 (5) when it was recognized as the vitamin curing pellagra.

A sixth vitamin of the vitamin B complex, biotin, has been isolated but thus far has not been synthesized.

At least 4 other members of this vitamin complex have been characterized but not yet isolated; two of them being necessary for the rat (6) and two for the chicken(7). Some of these may prove to be identical.

Choline, a compound long known to the organic chemist. is now commonly identified with the vitamin B complex. In addition, inositol,p-aminobenzoic acid and Peterson's eluate factor (8) or folic acid (9) have also been shown to be necessary for microorganisms and preliminary studies indicate that they may be of importance for higher animals. Thus vitamin B which was once

thought to be a single vitamin has turned out to be a complex of perhaps 14 or more separate vitamins or chemical entities. All These factors are present in whole grain cereals, yeast and liver.

FUNCTION OF THE VITAMIN B COMPLEX

Vitamins in general are not part of the tissue structures of animals, but seem to function in a catalytic capacity. Their function may be compared to the lubricating oil in a n automobile. The oil is not part of the structure of the automobile, yet it is absolutely necessary for its proper functioning.

Something is known of how three members of the vitamin B complex function. They are thiamine and nicotinic acid, both of which are the chief components of coenzymes and are referred to as prothetic groups. Riboflavine similarly is part of several enzymes often called "yellow enzymes" because riboflavine is a yellow pigment and it imparts the yellow color to the enzyme.(10) These vitamins as the key parts or prosthetic groups of enzymes and coenzymes are essential in the oxidation of glucose. Chemical energy which is essential to keep the body processes going, and therefore essential for life, is derived from the oxidation of carbohydrates and fats. Since very little is known about the oxidation of fats, we do not know whether any of the members of the vitamin B complex take part in that process. But it is definitely known that thiamine, riboflavine and nicotinic acid are part of enzymes and coenzymes which seem necessary for the oxidation of carbohydrates. The energy obtained from the oxidation of carbohydrates is made available to the cell as chemical energy, probably through the adenylic acid system (12). This assumes special significance in the light of the probable fact that brain tissue (11) oxidizes only carbohydrates, making the normal functioning of brain tissue and perhaps other nerve tissue dependent upon carbohydrate oxidation and therefore upon these members of the vitamin B complex. Proto plasm depends upon a continuous supply of energy to rebuild its component parts which are continually disintegrating as a result of destructive kotabolic processes always going on. Since nerve protoplasm must get its energy from carbohydrates, the integrity of nerve tissue and its ability to function normally depend upon adequate supplies of the vitamin B complex which are essential for the oxidation of these carbohydrates. It is therefore not surprising that one of the commonest and most constant manifestations of vitamin B complex deficiency is nerve disturbance of one kind or another.

VITAMIN B COMPLEX DEFICIENCY

The Biochemical Lesion.--Two types of nerve disturbances are encountered in animals when some of the members of the vitamin B complex are fed in inadequate amounts. These are acute and chronic. Acute nerve disturbances are cured immediately, often in a matter of hours, upon administration of the missing vitamin. Chronic nerve disturbances cure very slowly, and sometimes permanent injury results. Chronic nerve disturbances are readily explainable on the basis of nerve degeneration, since nerve regener-

ation is a slow process. Acute nerve disturbances cannot be explained in this way. Peters (13) has introduced the term "biochemical lesion" to explain the acute nerve disturbances in thiamin deficient p igeons. These nerve disturbances presumably occur in the nerve tissue of the brain and result in convulsions and head retractions commonly referred to as polyneuritis. Administration of thiamin cures polyneuritis in the pigeon in one to several hours. Two explanations are offered for this biochemical lesion. The first is the accumulation of intermiary products normally occurring when glucose is oxidized. A possible intermediary product in the oxidation of glucose to carbon dioxide and water is pyruvic acid. Thiamin is nexessary for the oxidation of pyruvic acid. In the absence of thiamin, pyruvic cannot be oxidized rapidly enough and accumulates in the brain tissue in such large amounts that it becomes toxic and interferes with the normal functioning of the brain tissue with the result that polyneuritis follows. Administration of thiamin causes the accumulated pyruvic acid to be immediately oxidized and the pigeon is cured of its convulsions.

Peters looks upon this explanation of the mechanism of the biochemical lesion as less likely than a second possible explanation. This is based upon the need of the brain tissue for a constant supply of energy which it can obtain only by the oxidation of the carbohydrate glucose or its polymer, glycogen. In the absence of thiamin from the diet, glucose or glycogen cannot be properly oxidized, and the brain cells do not have available the energy they need to function normally. When certain nerve tissues of the brain ceases to function for lack of energy, convulsions result. Administration of thiamin enables immediate resumption of the oxidation of glucose and energy is made available to the brain cells enabling them to resume normal function.

The Sparing Action of Fat on Thiamin.--Supporting evidence for the role of thiamin in the oxidation of carbohydrates is to be found in the observation that diets high in fat require less thiamin than diets high in carbohydrates (14). Presumably tissues like the muscles, heart, lung and kidney can obtain a t least part of their energy from the oxidation of fat, a process which apparently does not require thiamin. Since a smaller amount of carbohydrates is then oxidized, smaller a mount of thiamin are necessary.

This "sparing action" of fat on thiamin may explain why beri beri is such a common disease in the Orient, but relatively rare in this country. A consideration of the diets of the peoples of the Orient and those of the United States indicates that at least for large sections of the populations of these geographic localities there is little difference in the thiamin intake. The difference in the incidence of beri beri has been explained (16) by the difference in the fat intake of the peoples of the Orient from those of this country. The fat consumption of the people of the United States is higher than that of the Orient. This extra fat "spares" sufficient thiamin with the result that beri beri is comparatively unknown in this country while in the Orient it is widespread.

Difference in Thiamin Deficiency as Compared with Riboflavin, Pyridoxin, and Pantothenic Acid Deficiencies.--When rats are fed diets deficient in thiamin, they make a short initial growth until the bodily reserves of thiamin are exhausted, and then they immediately lose weight and quickly die. Rats fed diets deficient in riboflavin, pyridoxine, or pantothenic acid make an initial growth until the tissue stores of respective vitamins are used up, but instead of rapidly losing weight and dying, they maintain their weight for comparatively long periods and sometimes even gain slightly. They ultimately succumb, often without appreciable loss of weight. During this comparatively long deficiency period, they often develop lesions and degenerative changes. This type of deficiency is called chronic to distinguish it from the acute thiamin deficiency. Thus nerve degeneration could not be demonstrated in uncomplicated thiamin deficiency (16) while it is a common accompanyment of beri beri. Nerve degeneration in beri beri has not always been explained as due to thiamin deficiency (17) but to other complicating deficiencies. The only well authenticated case of nerve degeneration in uncomplicated thiamin deficiency has been in the fox upon feeding raw fish. Paralysis follows with lesions in the brain and is known as Chastek p aralysis (18). Nerve degeneration is common, however, in animals suffering from a chronic vitamin deficiency such as is encountered from lack of riboflavin, pyridoxine, and pantothenic acid.

Nerve Disturbances.--Nerve disturbances in animals deficient in the various members of the vitamin B complex vary with the animal and with the deficiency. Acute riboflavin deficiency in the dog leads to a collapse in which the brain seems to have lost its power to function normally. Administration of riboflavin quickly cures this collapse thus indicating the lesion to be of the biochemical type (19). Chronic riboflavin deficiency in the dog leads to nerve degeneration (19.). Nerve degeneration has also been demonstrated in riboflavin deficient chicks, and pigs. Nerve degeneration with partial paralysis has also been reported for riboflavin deficient rats (29). Pyridoxin deficiency in the pig results in chord changes (20). Nicotinic and pantothenic acid deficiency also lead to nerve degeneration (19). Paralysis resulting from nerve degeneration has been demonstrated in riboflavin deficient pigs and chicks and in pantothenic acid deficient pigs.

Skin Disturbances.--Skin changes are very common in animals deficient in the various members of the vitamin B complex (19). None have been associated with thiamin deficiency, but a dermatitis of one kind or another has been reported as follows: in the riboflavin deficient turkey and man; in the pyridoxine deficient rat and man; in the nicotinic acid deficient pig and man; in the pantothenic acid deficient chick and rat; and the biotin deficient chick (21) and turkey (22). In the riboflavin deficient rat there is a generalized loss of hair with a loss of sensual acuity in the skin (23) with the result that the rat is covered with lice without apparent disturbance. Normal rats will clean themselves of the lice.

In rats, foxes and dogs deficient in pantothenic acid

and perhaps some as yet unidentified member of the vitamin B complex, black fur turns gray. The depigmented areas assume patterns which are bilaterally symmetrical. Feeding pantothenic acid turns the fur black, but incompletely black, some other factors being necessary to turn the fur completely black.

Changes in the Gastrointestinal Tract.--Along with dermatitis and nerve degeneration, involvement of the gastro intestinal tract almost universally accompanies deficiency of the vitamin B complex. Loss of appetite is one of the commonest disturbances and is especially marked in thiamin deficiency. Diarrhea occurs in the pantothenic acid deficient dog and man and in the nicotinic acid deficient dog, pig and man. Ulceration and inflammation has been observed in the large gut of the nicotinic acid pig with atrophy of gastric secretory tissue sometimes followed by loss of hemopoietic activity of the gastric juice (19).

Anemia.--In the absence of dietary pyridoxin, the dog and pig develop a microcytic hypochromic anemia. In the pig in nicotinic acid deficiency a macrocytic anemia has been described with loss of power to make the pernicious anemia factor (24). Other vitamins which seem to play some role in maintaining a normal blood stream are riboflavin and pantothenic acid. Thiamin has not been shown to play any role in maintaining a normal blood stream, though such a possibility is by no means precluded.

Other Tissues and Vitamin B Complex Deficiency.--Riboflavin seems necessary for the proper functioning of the eyes. Among the disturbances in the eye resulting from riboflavin deficiency are twilight blindness and corneal lesions. In the eyes of some rats, cataracts will develop when they are deficient in riboflavin.

The internal organs including the kidney, hypophysis, spleen, ovary and thyroid seem to undergo surprisingly little change. Some grounds exist for the development of adrenal necrosis in rats when deficient in pantothenic acid. A condition described as "yellow liver" has been reported in riboflavin deficient dogs.

The heart rate is decreased in the thiamin-deficient rat. The condition is known as bradycardia. In thiamin-deficient rats there is dilation of the stomach and colon, indicating loss of tone. In nicotinic-acid deficiency there is in the pig a degeneration of the stomach tissue which elaborates the gastric juice.

Changes in Fetal Tissues.--Little has been reported on changes in fetal tissues when the mothers are deficient in the vitamin B complex.

Chickens on riboflavin-deficient diets do not deposit enough riboflavin in the egg for the development of a normal chick. The eggs do not hatch, and the embryos die with characteristic deformities: dwarf size, clubbed down, anemia, edema and degeneration of the Wolffian bodies. These deformities are sufficiently char-

acteristic that they can be used as a diagnostic symptom of riboflavin deficiency. Outbreaks of low hatchability of poultry have thus been correctly diagnosed, enabling the farmer to sharply increase the hatchability of his eggs by feeding the breeder hens more riboflavin.

Effect on the Efficiency of Food Utilization.--The most striking effect of the vitamin B complex on food utilization has been shown for the pig (25). On a ration of polished rice, casein, salts and cod liver oil, 703 pounds of feed were consumed per 100 pounds in weight of pig. Nicotinic acid alone had a great influence on the efficiency with which the pig converted feedstuffs into pig tissue, reducing the food consumed for a gain in weight of 100 pounds from 657 to 311 pounds.

Rather complete data are available on the role of riboflavin in the efficiency of food utilization by the chick. Without any added riboflavin chicks required 5.31 grams of feed to make a gain in weight of 1 gram. With the addition of 50, 100 and 150 micrograms of riboflavin to the feed, the feed consumed by the chicks to make a gain of 1 gram was reduced respectively to 3.50, 3.00 and 2.84 grams (27). Similar results have been reported for the rat (28).

Other members of the vitamin B complex have been similarly shown to influence the efficiency of food utilized.

In the present emergency it is important in the production of eggs, meat, milk and other animal foodstuffs to obtain the greatest possible efficiency of the feeds used. It is important not only because of the increased yield of these valuable and highly prized foods, but also because of the strain imposed on our transportation facilities. Every pound of feed wasted through inefficiency of food utilization means a pound of feed uselessly transported. Not only is the proper amount of vitamin B complex necessary for greatest efficiency of food utilization, but also the other vitamins, the proper amount and quality of proteins and minerals.

Mechanism Involved in Efficiency of Food Utilization.--Little is known of the mechanism by which food is lost to the body when deficient in vitamins. Only with riboflavin (vitamin G) (26) is there evidence which gives some insight into the physiological mechanism which results in a decreased utilization of food. The role played by riboflavin in the enzyme systems involving the oxidative processes have been discussed. When the animal lacks sufficient riboflavin to carry on normal oxidative processes, intermediary metabolites partly oxidized food substances accumulate in the blood and tissues and some of these incompletely metabolized food substances are excreted in the urine and lost to the animal for productive purposes. These partly oxidized compounds have been found in the urine of riboflavin-deficient rats leading to an increase in the carbon:nitrogen ratio. The same has been demonstrated for thiamin.

BALANCE AMONG THE MEMBERS OF THE VITAMIN B COMPLEX

The balance among the members of the vitamin B complex is of 2 types. One type of balance which will be referred to as interrelationship involves mutual influences of vitamins among themselves and with other foodstuffs without any deleterious effect of any vitamin. The second type of balance will be referred to as "imbalance" since the vitamins in question under the conditions described are deleterious.

Interrelationships.--The relation of fat to thiamin has already been explained on the basis that thiamin is required for the oxidation of carbohydrates and when the carbohydrates are replaced by fats, the amount of thiamin required is reduced.

Since riboflavin is also part of the enzyme systems required for the oxidation of carbohydrates it would seem logical to assume that replacement of carbohydrates with fat should decrease the riboflavin requirements of riboflavin (30).

Acrodynia or dermatitis in rats occurs readily on fat-free diets supplemented with thiamin and riboflavin. The dermatitis can be cured more readily when both pyridoxin and linoleic acid are fed together than when either one alone is fed.

In the absence of linoleic or arachidonic acid (essential unsaturated fatty acids) pyridoxine will not completely cure the dermatitis. The combination of pyridoxine and pantothenic acid are more effective but the cooperation of another as yet unidentified factor is essential for the complete cure of dermatitis in rats on a fat-free diet. Both fat soluble and water soluble substances seem necessary for the most prompt and effective cure of dermatitis. The term "sparing action" of fat on vitamin B_6 (32) has been applied to this phenomenon.

Imbalance among the Members of the Vitamin B Complex.--The greying of hair in rats is a skin disturbance which manifests itself in depigmentation of the hair. Pantothenic is one of the factors which largely prevents or cures the condition while pyridoxin aggravates it. Pyridoxine also aggravates cortical necrosis on low-choline diets.

Riboflavin acts in a deleterious capacity in that it aggravates the dermatitis in pantothenic acid deficient chicks. It also acts in a deleterious way under certain experimental conditions when its addition decreases egg production and hatchability.

On the other hand, roboflavin acts in a favorable capacity by decreasing or preventing liver cancer produced by feeding dimethylaminoazobenzene. In this case biotin, another member of the vitamin B complex, acts in a deleterious way by encouraging the browth of the liver cancer.

In the dog on synthetic diets, withholding both panto-

thenic and nicotinic acid enables the dog to get along better than withholding either nicotinic or pantothenic acid.

Guinea pigs on high cholesterol diets will deteriorate more rapidly and die sooner when large quantities of riboflavin and pantothenic acid are added to their diets.

In selenium intoxication of the dog, the daily injection of small doses of thiamin made the intoxication more severe with increased degeneration of the liver (33).

The reality of imbalance among members of the vitamin B complex can no longer be doubted. Addition of certain members of the vitamin B complex to diets which are faulty in one way or another may cause harmful effects.

COMPLEXES

Some members of the vitamin B complex are so tightly bound by other chemical compounds that the vitamin is unavailable to the organism. The best known case of this kind is the complex that biotin forms with a protein known as avidin which is present in egg white. When egg white is mixed with foods containing biotin the avidin of the egg white ties up the biotin, causing serious injury to the animal with a very severe dermatitis as the most prominent symptom. This injury is simply a biotin deficiency and can be cured by pure biotin. The avidin-biotin complex is not broken up by the digestive tissues, but is readily broken up by heat. Heating egg white or avidin destroys the ability of the avidin to combine with biotin. Apparently avidin is a protein so that heat coagulates it and so changes its nature that it loses its power to combine with biotin.

Vitamins seldom exist in tissues as such, but as complexes of various kinds, most of them not well understood. Higher animals seem to have the ability to break up most of these complexes during digestion. Microorganisms do not have the same ability to break up these various complexes. Vitamin assays of food made with both microorganisms and chicks or rats will sometimes differ widely because the microorganisms cannot break up the complexes and therefore cannot utilize the bound vitamin whereas the chick or rat can do so.

THE ROLE OF MICROORGANISMS

<u>The Use of Microorganisms For the Assay of The Various Members of The Vitamin B complex.</u>--Great progress has recently bee n made in developing methods for the assay of the riboflavin, pantothenic acid, biotin, and folic acid. Lactobacillus casei E has been the most successful organism, though other organisms have al- s o been used. Thiamin has been assayed successfully with yeast as the test organism. Nicotinic acid has also been recently assayed microbiology. Pyridoxin is the only member of the vitamin B complex which apparently cannot be assayed microbiologically

with results at all comparable with those obtained with rats. The divergence between results of pyridoxin assays obtained microbiologically and with rats has been so great that one or the other method may not actually assay the pyridoxin. The validity of the rat-assay method for pyridoxin has been questioned.(34)

Herbivora and Microorganisms.--Herbivorous animals, especially ruminents, have spacious gastrointestinal tracts, especially the rumen in w hich there is a great activity of microorganisms. The ruminent provides the space for growth of these microorganisms and also food, especially nitrogenous compounds and fermentable carbohydrates. Many of these organisms utilize the carbohydrates ordinarily unavailable such as cellulose and the hemicelluloses. The microorganisms have great synthetic cap acity, converting foodstuffs of low value into vitamins and proteins of high biological value. Every member of the vitamin B complex, including thiamin, riboflavin, pyridoxin, nicotinic acid, pantothenic acid and biotin is now known to be synthesized in the rumen of the ruminant and has made it independent of its food supply for the vitamin B complex which it needs for its metabolism and for incorporation into the milk it secretes. Populations, especially infants and growing children are greatly indebted to these microorganisms which have supplied them with the vitamin B complex through the cooperation of the cow.

Microorganisms and Non-herbivora.--The only instance in which a non-herbivorous animal has been known to become independent of its food for its supply of the vitamin B complex is the rat which has become "refected" (35). Rats fed raw starch such as potato or rice starch without any vitamin B complex usually lose weight rapidly and die. Some of these rats will suddenly start to eliminate large white bulky feces and at the same time start growing, often quite normally. Certain microorganisms have taken up their abode in the gastrointestinal tracts of these rats, and they synthesize the vitamin B complex the rat needs. In the metabolism of these microorganisms, the starch granules have been acted upon, making them impervious to the digestive juices of the rat and therefore quite undigestible. This undigested starch is the source of the bulky white feces which accompanies "refection" in the rat. Heating the starch before feeding it so changes it that "refection" is no longer possible.

Microorganisms are known to play additional roles in influencing the animals requirements for the vitamin B complex. Feeding cooked starch to rats causes the synthesis of pantothenic acid in the rats gastrointestinal tract and lactose causes the synthesis of pyridoxin and riboflavin. In each case, the carbohydrate stimulates the growth of those microorganisms which synthesize for the rat the vitamin in question; namely, starch, the pantothenic acid; and lactose, the riboflavin and pyridoxin. Sucrose seems to have no power to stimulate the growth of any helpful microorganis ms, especially in so far as the vitamin B complex goes.

<u>Microorganisms as Preservative Agents</u>.--Microorganisms, especially of the lactictype have been used for centuries to preserve foods, as in sauerkraut, dill pickles and sour milk. Green food is highly prized by poultrymen, but it is highly seasonal. Moreover, green food varies greatly, depending on weather conditions and stage of growth. The perfection of the methods for making silage from green food has put at the disposal of poultrymen the means of preserving and storing green food at its highest nutritive value. Where a lactic fermentation is used, the synthetic activity of the organisms may add still further to the nutritive value of the food.

The possibilities of putting the great synthetic capacity of microorganisms to work for the benefit of man is slowly being appreciated, and we can look forward to great developments along these lines .

REQUIREMENTS

Complete data on the requirements of different animals for all the members are not a vailable. Most of the information available is shown in the table. The requirements are expressed in different ways for different animals.

REQUIREMENTS FOR THE VITAMIN B COMPLEX

Animal	Thiamin	Riboflavin	Nicotinic Acid	Pyridoxin	Pantothenic Acid
rat-micro-grams daily	10	13-17	None	10-20	100-150
dog-micro-grams per kilo body weight	20-40	25-50	250	60	
chicken-micro-grams per 100 grams of diet	150	200-250	None	Uncertain	600-1400
Pig-mgs daily per 100 pounds of pig	1	1-3			10
human - mg daily	1.5	2-3	10-20	1-2	5-10

It is obvious from the table, the rat and chicken do not need nicotinic acid, since they presumably are able to synthesize the nicotinic acid they need.

LOSSES OF THE VITAMIN B COMPLEX

Losses in Cooking.--Among the pertinent chemical properties of the vitamin B complex is the solubility of all of them in water, even though they all differ chemically from each other. They vary in their stability to heat. Thiamin is the least stable, since it can be completely destroyed in foods by autoclaving. Riboflavin and pantothenic a cid will not be destroyed readily by heat, but both will be readily destroyed by heat in an alkaline medium. While all the vitamins are fairly stable to oxidation, continuous exposure to oxidative processes is more or less destructive, especially to biotin. Riboflavin is destroyed on exposure to light.

In cooking, these chemical properties must be kept in mind if excessive losses of these vitamins are to be avoided. If an excess of water is used to cook the food and the water discarded much if not most of the vitamin B complex is thrown away with the water. The food should be heated only long enough to properly cook it, since progressive destruction of the vitamins, especially thiamin, goes on as the food is being overcooked. Adding soda to the cooking water is especially destructive to thiamin, riboflavin and pantothenic acid, and does the rest of the vitamins no good.

Losses from Inability of Storage in Body Tissues.--The vitamin of the B complex is not stored in the tissues to any extent, apparently because they are soluble in water. Fat soluble vitamins, on the contrary, can be stored in large amounts, especially in the liver. The inability to store the vitamin B complex in the tissues is a disadvantage to the organism since vitamins eaten in excess of the body needs are not stored but excreted. This may not be altogether bad since ingestion of large amounts of these vitamins cannot exert toxic effects, the excess being excreted.

Losses in Manufacture and Handling.--Manufacturing processes are often destructive to the vitamin B complex. Canning involves exposure to heat which is destructive, especially to thiamin. If soda is used to preserve the green color of vegetables, thiamin, riboflavin and pantothenic acid are destroyed. If the water in the can is discarded, the vitamins dissolved in the water are lost.

Dessication of foods brings with it many problems. Sulfuring of fruits destroys the thiamin. Blanching of fruits and vegetables has both advantages and disadvantages. The whole problem of dessication is not well understood and is now the subject of an intensive investigation all over the country as an emergency war project.

Losses in Milling.--The greatest losses of the vitamin B complex result from milling wheat which removes most of the known factors of the vitamin B complex, and perhaps others as yet unknown. In addition to the loss of the vitamin B complex, there

are also removed from the wheat berry in the manufacture of white flour, important minerals, fats, and proteins of higher quality than that left behind. History records no other instance where a food of such high biological value as wheat has been reduced by man of his own free will to white flour which is a food of such low biological value. It must be remembered that the milling of wheat was not accidentally introduced. It was introduced partly because people demanded a white flour which to them was more palatable than whole wheat flour, and partly because of the problems of handling whole wheat flour. With the concentration of large populations in cities, flour had to be transported long distances and stored for long periods of time. Whole wheat flour spoiled more readily than white flour and was shunned by food merchants.

The milling processes were developed at a time when man was ignorant of the disastrous effect the processes would have upon the nutritive value of one of the chief ingredients of his diet. With the development of our nutritional information, the losses to our diet by milling the wheat became and are becoming increasingly more evident. Man has now an incentive to learn how to handle whole wheat flour without allowing the spoilage which was responsible in such large part for milling wheat. The solution to these problems can undoubtedly be found if there is a sufficient demand for whole wheat bread.

DISTRIBUTION OF THE VITAMIN B COMPLEX IN FOODS

Animal Sources.--Foods from animal sources: meat, fish, milk, and eggs are all more or less good sources of the vitamin B complex. They have long been known as "protective foods". Glandular meats, more especially the liver and kidney, are very good sources of the vitamin B complex. The liver and roe of fish rival in excellence of the nutritive value of liver and kidney. Meat products are not equally good sources of all the members of the vitamin B complex. Thus, liver and kidney are outstandingly good sourcds of riboflavin, pantothenic acid, nicotinic acid, but only fair sources of thiamin. Muscle meats are fair sources of the whole vitamin B complex.

Eggs, especially the yolk, are good sources of the vitamin B complex. Egg white is good source of riboflavin but a poor source of the other members of the vitamin B comples.

Milk is only a fair source of the vitamin B complex with the exception of riboflavin for which it is a good source.

Because of the quantity of meat and milk consumed, they furnish an important part of our needs for the vitamin B complex and could well supply completely our needs for some of the vitamins.

Plant Sources.--The whole grain cereals are man's most important source of the vitamin B complex. Because of the large intake, especially of wheat and other cereals, man's needs for the vitamin B complex can be nearly met from this source alone, Only

riboflavin might not be ingested in adequate amounts, but an important part of our needs of riboflavin would nevertheless be supplied by the cereals. Milk admirably supplements the whole grain cereal since it is rich in riboflavin. Corn seems to be low in nicotinic acid as compared with wheat.

Vegetables are not particularly outstanding sources of the vitamin B complex. Green leafy vegetables are reasonably good sources of riboflavin but are only fair or poor sources of the other members of the vitamin B complex, a possible exception might be folic acid of which too little known is known at present.

Not all vegetables are of equal value. The tomato is one of the more important vegetables. The legumes, especially soybeans and peanuts are good sources of the vitamin B complex. Leafy green vegetables are good sources of riboflavin.

VARIATION OF THE VITAMIN B COMPLEX IN FOODS

Variation in foods from plant Sources.--It is only recently that we have realized that the vitamin content of foods vary greatly, depending on the soil upon which they are grown, on the state of maturity, on the variety and on climatic conditions such as temperature, rainfall, sunshine and humidity. Some soils are known to yield foods of higher nutritional value than others. The state of maturity of crops has a great bearing on their nutritive value. The cereal grasses are of far greater nutritive value before jointing than after. Alfalfa has different nutritive values before the bloom stage, at the bloom stage, and after the bloom stage. In general, tender greens have greater nutritive value before lignification than after, presumably because lignified cellulose is undigestible and locks up much nutritive value, whereas unlignified cellulose is partially digested, releasing food factors bound up with the cellulose.

Variation in foods from Animal Sources.--In general, animal foods such as meat and eggs will va ry in their vitamin B complex values, depending on the vitamin content of the feed. Variations of 200 to 300 per cent have been found in meat and eggs, depending on how the animals were fed. The vitamin B complex of milk of the cow should not be influenced by the vitamins of the feed, since the vitamin B complex is synthesized in the rumen of the cow. Yet, unaccountable variations are found in milk, depending often on the section of the county the milk comes from and on other ill-understood variables. The vitamin content of the milk of women and other non-herbivorous animals is dependent on the vitamin content of the food.

Effect of the vitamin B complex of the Feed on the Nutritive Value of Meat other than its Content of the Vitamin B Complex.--Not only does the vitamin content of the feed influence the respective vitamin content of the meat, but it may also influence the nutritive value of the meat in other ways. There is one well authenticated instance of such a case and it has been dis-

cussed under anemia in pigs presumably deficient in nicotinic acid. The liver of such deficient pigs does not have the anti-pernicious anemia principle. This has been shown by preparing liver extracts from the livers of normally fed pigs and those deficient in nicotinic acid. The extracts from the normally fed pigs will cure pernicious anemia in man, but the liver extract from the deficient pigs will not (24).

It is not impossible that vitamin deficiencies of the diet will effect the nutritive value of meat in other ways than increasing or decreasing the respective vitamin of the meat.

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METHODS AVAILABLE FOR ASSESSING NUTRITIONAL STATUS

by A. L. Marlatt, B. Kennedy and others, Department of Home Economics
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For a number of years height-weight and other anthropometric measurements, plus physical and dental examinations have been the accepted methods of determining nutritional status of school children as well as of adults. These measurements, however, pick out the malnourished individual only after organic changes, often irreparable, have occurred. They also may indicate that malnutrition has existed at some time during the child's development, but say nothing of his present nutritional state.

Dietary studies do not give an accurate picture of the nutritional adequacy of any individual's diet, although they may give valuable information concerning nutritional deficiencies in the diets of families and groups.

The need then has been for tests which will point out functional deficiencies before organic changes occur. Very recently, biochemical tests have been developed which pick up these subclinical deficiencies by measuring the levels of the nutrients, especially minerals and vitamins in the blood and urine.

Extensive nutritional status studies using these technics have already been carried out in the Pennsylvania State College Studies (3) and the Milbank Studies (4).

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DETECTION OF NUTRITIONAL ANEMIA

by M. Winkelman

The general methods for the determination of hemoglobin in blood are

1) Direct iron determination. In the Wong method the iron is detached from the hemoglobin molecule by treatment with sulfuric acid and potassium persulfate and then determined (continued page 3)

The status of the individual with reference to the following nutrients may be assessed:

Nutrient	Method	Value
Protein	Serum protein determination	Significant
Iron and other blood building substances	Hemoglobin and blood count	Significant
Calcium and bone development	X-rays; serum Ca, inorganic P and phosphatase	Significant
Vitamin A	Blood vitamin A and carotene; Dark adaptation; Slit lamp examination of the eye for corneal or conjunctival changes	Probably significant
Ascorbic acid	Plasma ascorbic acid; urinary excretion after administration of a massive dose of the vitamin	Significant
Thiamin	Urinary excretion after administration of a massive dose of the thiamin; thiamin or pyruvic acid level in blood	Significant
Riboflavin	Examination of eye by slit lamp for corneal vascularity; blood and urine content of riboflavin before and after administration of massive dose	Probably significant
Nicotinic acid	None	
Pantothenic acid	Blood and urine examination	Of doubtful value
Pyridoxine	Blood and urine examination	Of doubtful value
Vitamin K	Prothrombin value of blood	Probably not significant

colormetrically by the thiosyanate reaction. Probable error ± 2%

2) Acid Hematin. The blood is diluted with hydrochloric acid and depth of color of the resulting solution is compared with a standard acid hematin solution (Haskins Sahli Method - probable error ± 15%) or with a brown glass plate (Newcomer - probable error ± 12%)

3) Van Slyke Oxygen Capacity. This is an accurate (± 1%) and time consuming method used for research purposes and for standardization of more rapid methods.

4) Photoelectric methods. Hemoglobin is determined directly from the light conduction of diluted blood. The methods are quick and accurate if the photoelectric cell is in good working order, However, unless the cells are checked frequently the errors may be very large.

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Wintrobe (1) found on analysis of the literature that the average and range of normal values were

	Red Blood Cells in million/ml	Hemoglobin in gm/100ml blood	Red Cell Volume %
Men	5.4 (4.6-6.2)	16 (14-18)	47 (40-54)
Women	4.8 (4.2-5.4)	14 (12-16)	42 (37-47)

The normal range for adults is well established but the standards for children are not yet well established. The Milbank Fund investigators (2) studied a selected normal group of boys and girls 12 to 18 years to establish normals for a later study. It was found that there is considerable variation in averages with age.

Mack (3) using the Newcomer method found lower hemoglobin values in children in a low socio-economic group than in a higher socio-economic group. For other evidence of the incidence of anemia see 1 941 Proceedings of the Defense Nutrition Institute, page 32.

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METHODS OF ASSAYING NUTRITIONAL STATUS OF HUMAN SUBJECTS AS TO VITAMIN D AND CALCIUM
by Jenieve E. Hollingsworth

The methods which have been used to determine nutritional status of vitamin D and calcium have included, 1) the chemical determination of serum calcium, phosphorus, and phosphatase, 2) the biological estimation of the blood level of vitamin D, and 3) the rating of the mineralization of the bones using X-ray pictures.

Serum calcium can be determined by the Clark-Collip method (1). Normal values range from 9 to 11.5 mg. per 100 ml. blood. Values below 9 mg. per 100 ml. of blood are subnormal. When inorganic serum phosphate is determined by the method of Fiske and Subbarow (2) 5 mg. per 100 ml. are considered normal. In rickets values are found to be 3 mg. percent or less. Blood phosphatase values as determined by the Bodansky method (3) are from 4 to 10 Bodansky units per 100 ml. for normal subjects. The serum phosphatase level rises rapidly in a vitamin D deficiency and returns to normal after all other signs of deficiency have disappeared. The range of values obtained in severe cases of rickets is from 14 to 57 Bodansky units with a mean value of 28 units. In mild cases the range is 7 to 16 units with a mean of 11 units.

As there are no accurate and specific chemical methods for determining vitamin D, Warkeny (4) has attempted to use the line test method with rats to determine the normal blood level. For normal subjects he obtained a range of values from 46 to 165 I.U. per 100 ml. of serum, with a mean value of 116 I.U. per 100 ml. This method is laborious and subject to many errors, such as litter differences and individual variations of the rats. However, the chief difficulty is the impossibility of getting enough serum from one person, especially when the donor is a child, to be able to use a large enough number of rats in the testing to make the results statistically significant.

The work done by T. W. Todd in the field of X-ray determination of bone maturation which culminated in the publishing of his Atlas of Skeletal Maturation of the Hand (5) opened the way for later workers. His published standards of bone maturation covered the age of 3 months to 16 years for girls and 3 months to 19 years for boys. With this beginning the Pennsylvania workers have amplified the standards so that they also covered the age range from birth to three months. The method can be used to judge not only bone maturation but also mineralization of the bones. Todd introduced the use of the graduated wedge which can be X-rayed with each film and later used in judging the uniformity of exposure and processing of each film. This is particularly important when a whole series of films is to be compared with the established Todd standards. To eliminate the subjective and personal factors in interpreting X-rays, which have greatly hindered their use in nutritional studies, the Pennsylvania workers (6) have developed a microphotometer which will travel at a uniform speed across a given area of an X-ray film and record graphically the density of bone minerali-

zation. This graph can be measured, compared with the accompanying graph of the graduated wedge, and the density of the mineralization of a given child with the standard or with his own previous rating, and makes it possible for different workers to get results which check.

As the standards for mineralization of children and adults become more complete and more laboratories have access to microphotometers our ability to determine nutritional status as to calcium and vitamin D will become more accurate. The use of X-rays of the bones and subsequent comparison with standards for maturation and mineralization will probably be the method used in the future and is the most promising of all the methods now available.

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METHODS OF ASSAYING VITAMIN A STATUS OF HUMAN SUBJECTS
by Fern Lacy

1. Blood methods

The standardized methods of determining blood content of vitamin A and its precursor carotene require a blood sample of 7-10 ml. The p lasma is separated from the whole blood and 3.5-5 ml. of the plasma is extracted with alcohol and light petroleum ether. Other fat solvents ma y be used but the two named are generally employed. The extraction mixture is centrifuged to separate the alcohol and ether into layers. Carotene may be estimated in the ether layer by its own yellow color as read in a colorimeter, a photocolorimeter or a spectroscope. Vitamin A is colorless but reacts with antimony trichloride to form a blue-colored substance which may be read in the above instruments or in a Lovibond tintometer.

There have been no comprehensive assays of human blood

levels of vitamin A. One study on thirty men and thirty-four women (N. S. Kimble) gave average concentrations of 129 I.U. of A per 100 ml. of plasma for men and 91 I.U. of A per 100 ml. of plasma for women. This sex difference was consistent through the sample. Plasma carotene concentrations determined on the same men and women were variable, with no constant correlation between plasma A and carotene. Carotene determinations are of doubtful value as indications of body vitamin A status. There are no figures available on children's blood vitamin A ranges.

Blood levels of vitamin A are subject to long range influences of the diet, to changes in metabolic rate as with fever, to infections, to diseases causing liver and kidney damage (including diabetes) and to ingestion of alcohol as long as four days before testing. All attempts to determine "normal" ranges must consider the influence of these factors.

It has not yet been possible to show correlation between specific blood levels of vitamin A and specific rod thresholds in dark adaptation tests (see below). It is probable that variable liver storage of vitamin A as well as the lag period between A in the blood and the formation of visual purple make blood A subject to short time fluctuations not carried over to dark adaptation reactions.

2. Dark adaptation (eye) tests.

Experimental evidence has demonstrated that a deficiency of vitamin A results in a delayed ability to perceive a second flash of light after the eyes have been exposed to a strong first beam. This is the basis of the many instruments devised to correlate dark adaptation with vitamin A status of a subject.

There are in general two types of determinations possible. After the subject's visual-purple has been bleached by having a bright light turned in his eyes for a specified time (usually 3 minutes), the light is turned off so that the subject is in total darkness and the investigator may determine the time required for the eyes to adapt themselves so that they are able to perceive a light of given intensity (Pett-LePage apparatus, Feldman apparatus). The second method determines the lowest intensity of light which is just perceptible by the subject at specified time intervals after the bright light is turned off. (Biophotometer, Regenometer, Hecht-adaptometer, Hecht-Shlaer adaptometer, Birch-Hirschfeld Photometer.) The recovery time type of dark adaptometer test is stated by some to be of little value for detecting states of vitamin A deficiency. Two well-nourished healthy subjects tested by both methods were shown to have the same complete course of dark adaptation and the same final rod threshold. By the recovery-time type of test, however, they appeared to differ significantly. This would indicate large subjective errors in the latter type of test.

3. Conjunctival (eye) spots.

Slit-lamp microscopy has been proposed as a method of detecting mild avitaminosis A through changes in the conjunctiva and cornea of theeye. However, such changes do not always appear early in the course of this deficiency and do not lend themselves readily to quantitative evaluation.

4. Skin signs.

Medical diagnosticians have reported cures of skin conditions resembling acne by administration of vitamin A and some have attempted to correlate appearance and severity of the skin lesions with other signs of A deficiency. One study showed that dietary cures of these skin conditions were accompanied by progressive increase in ease of dark adaptation. The correlation, however, was not quantitative. The changes a re not regular in appearance.

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ASCORBIC ACID STATUS OF HUMAN SUBJECTS
by G. S. Bodenhamer

At the present time, methods being used clinically for determining the nutritional status in relation to ascorbic acid are:- 1) blood and urine ascorbic acid level determinations; 2) use of test doses of ascorbic acid to estimate the degree of tissue saturation in conjunction with blood a nd urine ascorbic acid level determinations; and 3) capillary fragility tests, of value only when used to correlate evidence obtained from the other methods.

While there are methods for the determination of the

ascorbic acid content of whole blood, there is none at present which is simple enough to be used routinely in clinical work. (1) The majority of clinical studies employ the blood plasma ascorbic acid methods, which may consist of simple titrations with the dye, 2, 6, dichlorophenolindophenol of plasma filtrates after precipitation with metaphosphoric acid, (2), (3), or make use of the photoelectric colorimeter. (4)

Urine ascorbic acid levels are determined most accurately using aliquot samples of 24 hour collections. Due to interfering reducing substances present in addition to the ascorbic acid in urine, the use of a photoelectric colorimeter which will give more accurate immediate readings than visual titration is desirable. Evelyn's method for determination of urine ascorbic acid is most widely used. (5) It has been found that urinary output of ascorbic acid is a poor indication of deficiency of the vitamin, but it does reflect the intake in a saturated individual.

The use of a test or saturation dose of ascorbic a cid, as described by Ralli and Sherry in their review article, (6), is also used clinically, when the subjects are available for the necessary control and time involved. Urinary excretion determinations are made following a test dose of ascorbic acid. Blood plasma ascorbic acid levels are also determined.

Capillary fragility tests have been used for some time as an indication of scorbutic states, but should be used only in conjunction with blood plasma and urinary excretion studies, since there is no positive correlation between all capillary fragility and scorbutic symptoms. Wright and Lilienfeld describe the use of this test. (7)

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THE THIAMIN STATUS OF HUMAN SUBJECTS
by Abby L. Marlatt

The importance of thiamin in nutrition is based on its role in the enzyme system associated with the intermediate metabolism of carbohydrates. The enzyme which contains thiamin is known as cocarboxylase or diphosphothiamin. Its specific role is the decarboxylation of pyruvic acid. Thus in thiamin deficiency and especially in berberi, levels of pyruvic acid in the blood and in the urine are increased.

Food as ingested may contain thiamin or cocarboxylase - in general, plants contain the free thiamin, but animal tissues contain the combined form, cocarboxylase. After absorption excess amounts of thiamin are carried in the serum, but this is quickly phosphorylated (converted to cocarboxylase) so that most of the thiamin appears in the blood as cocarboxylase and is located in the formed elements - red cells and white cells. Excess thiamin above the daily requirement is not readily stored but is excreted as free thiamin in the urine; (cocarboxylase is transformed to free thiamin by the kidney enzyme, phosphatase). The ingested thiamin which escaped absorption in the small intestine and that which may be formed by the flora of the large intestine, is eliminated in the feces.

The nutritional status of an individual in regard to thiamin may be determined by measuring 1) the thiamin excreted in the urine, 2) the free or total thiamin of the blood, or 3) the pyruvic acid level in the blood. These measurements may be made on an individual either under his normal regime or after a test dose of thiamin has been administered.

1. <u>Urinary excretion of thiamin.</u>

Thiamin excretion in normal adults ranges between 100 and 300 micrograms per 24 hours. In deficient subjects, especially those with alcoholic polyneuritis, excretion may fall to zero but often is between 15 and 30 micrograms per day. However, in assessing nutritional status, the test dose method is preferred because urinary excretion for a 4 or 5 hour period after a test dose tends to reflect the existing thiamin saturation of the tissues, while a single 24 hour excretion test only reflects the adequacy of the thiamin intake of the previous day. The former also has the advantage of speed, and the elimination of the inconvenience and uncertainty of the 24 hour collect on non-hospitalized subjects. The test dose of thiamin may be given orally - 0.1 mgm per kilo body weight with the largest meal. In normals 8-10% of the test dose is excreted in 5 hours (1); less than 4% excretion denotes a deficiency. The factor of variation in thiamin absorption has been eliminated by injecting the test dose, usually 1 mgm, intravenously or intramuscularly (2), (3).

Several chemical methods are available for determining the thiamin content of urine. Melnick and Field (4) have used the diazo method but its lack of sensitivity makes it necessary to

have a 24 hour urine sample for analysis, and the process of concentrating this sample is time-consuming and not clinically practical. The yeast fermentation method used by Pollack (3), while simple and quick, is not specific for thiamin; the yeast can also utilize its split products, - thiazole and pyrimidine. Therefore values reported by this method are always high. The bacteriological method of Williams (5) is objectionable for the same reasons.

The most practical and specific method now available for chemical use is the thiochrome method (6). In this method, thiamin is oxidized to the fluorescent blue pigment, thiochrome, by alkaline ferricyanide in isobutanol; the fluorescence is best read in a photofluorometer though a simple visual comparator may also be used (1). The thiamin in a small sample of the urine is freed from interferring pigments present by absorbing it on zeolite either by running the solution through an absorption column (6) or by shaking the solution with the absorbate (1).

2. The thiamin of the blood.

The value for total thiamin (free thiamin plus cocarboxylase) of the blood seems to be a valid criterion of nutritional status as regards thiamin. However, the levels are very low, 6 to 16 micrograms per 100 ml for normal cases and below 5 micrograms for deficient ones. Here again the fermentation method is sensitive but not s pecific (7). The thiochrome method determines only free thiamin (2), therefore total thiamin may be determined only after digestion of the sample with diastase which released free thiamin from the enzyme (8). A test dose method which is still in the experimental stage requires the intravenous injection of a 50 mg dose of thiamin; the blood level of free thiamin is then measured at 10 minute intervals over the course of an hour(2).

3. The pyruvic acid of the blood.

Measurements of the level of pyruvic acid in the blood indicate that all values above 1 mg pyruvic acid per 100 ml blood are associated with hypothiaminosis (9). Beuding and Wortis (10) have developed a glucose tolerance test in which they inject 1.75 gm glucose per kilo and then measure the elevation of the blood pyruvic acid level. In normal subjects the pyruvic acid level of the blood returns to normal in 3 hours, in thiamin deficient subjects it remains elevated. Pyruvic acid is best determined by converting it to its phenylhydrazone and reading the resulting color in the photoelectric colorimeter (11).

At present the most practical method available for assessing thiamin status of a large group of people seems to be the thiochrome determination of the percent of thiamin excreted in the urine during the 4 hours following a 5 mg oral dose of thiamin.

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RIBOFLAVIN STATUS IN HUMAN SUBJECTS
by Marian B. Smith

Riboflavin nutritional status may be evaluated in several ways 1) by riboflavin levels in blood and urine, 2) by saturation tests, and 3) by biomicroscopy of the eye using slit-lamp illumination.

According to Sydenstriker (1) the earliest clinical manifestation of ariboflavinosis is a superficial vascularizing keratitis extending into the cornea of the eye. The extent of the vascularization when evaluated quantitatively has been used clinically to determine riboflavin status (2).

Several methods are available for studying blood and urine levels of riboflavin in humans. The microbiological method of Snell and Strong (3) has been used in determining urinary excretion levels. This method consists in measuring the turbidity and lactic acid produced by Lactobacillus casei E on basal synthetic media. The advantages of this method are in its rapidity and its marked specificity. As yet the method has not been modified satisfactorily for the determination of blood riboflavin levels.

The fluorometric methods are based on the measurement of the fluorescence of riboflavin or its degradation products - lumichrome or lumiflavin. Najjar (4) has recently developed a modification to avoid difficulties encountered with turbidity of solutions and gaseous emulsions. The riboflavin, separated from the aqueous medium by preferential absorption in pyridine and butyl alcohol, is measured by fluorophotometry. Conner and Straub's (5) modification determines both thiamin and riboflavin. In their

preliminary treatment of the sample, thiamin is adsorbed on the upper decalso section and riboflavin on the lower supersorb section of the double adsorption column.

Riboflavin excretion itself does not seem to be an adequate measure of riboflavin status as the excretion seems to depend very closely on the immediate intake. Ferrebee (6) found a variation in normal subjects of 700-1700 micrograms per day.

Saturation tests as used recently by Sebrell (7) and Axelrod (8) show promise. Najjar (4b) has also developed a test dose method in which he measures the riboflavin level in the serum after a standard injection.

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NICOTINIC ACID AND NUTRITIONAL STATUS TESTS

by Barbara Kennedy

There is at present no satisfactory way of determining the status of an individual with respect to nicotinic acid. Chemical and bacteriological methods of measuring nicotinic acid and related compounds are available but neither blood nor urine studies have as yet proved valuable in detecting deficiency cases. As the coenzyme is necessary for life, it is not decreased even in severe conditions.

In both normals and pellagrins, the level of total nicotinic acid (nicotinic acid, Nicotinamide, and coenzymes I and II)

in the blood as determined by chemical and bacteriological analyses is between 0.6 and 0.9 mg per 100 ml of whole blood, and in both, test doses of nicotinic acid cause a rise in plasma nicotinic acid which rapidly returns to normal.

The urinary excretion of total nicotinic acid is between 3 and 5 mg per day. An attempt has been made by Briggs to use the urinary excretion of nicotinic acid after a test dose as a means of studying the nicotinic acid status. He did not succeed in distinguishing controls from pellagrins. Chemical methods were used. Urinary excretions, however, hold more promise than do blood levels.

The ether-soluble red pigments in urine of pellagrins have been shown by Kark and Meiklejohn to be non-specific for cases of nicotinic acid deficiency.

The only means of studying cases of deficiency at present are by the general state of health, with particular reference to anemia, mouth conditions and dermatitis, the causes for which are not at all limited to an inadequate intake of nicotinic acid.

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PYRIDOXINE STATUS IN HUMAN SUBJECTS
by Doris Chatlin

Pyridoxine deficiency is usually associated with a deficiency of the entire B complex. In human deficiency cases, besides such general symptoms as nervousness, insomnia, irritability, and weakness, Spies (2,3) has observed muscular rigidity with difficulty in walking, and Smith (1) reports a cheilosis which does not respong to riboflavin.

Methods of measuring pyridoxine in blood and urine are microbiological using yeasts or molds, and chemical. The chemical method most widely used is that of Scudi (4) based on the Gibbs phenol reaction. The unmodified method for free pyridoxine is not specific, therefore interfering substances (including ascorbic acid) should be removed by adsorption (6). Conjugated pyridoxine is included only after acid hydrolysis (5).

Because of the non-specificity of the method, blood levels and urinary excretion values are not valid measures of nutritional status. However, urinary excretion following a 50 mg injected dose has been determined by Spies (2). He found that nor-

mal subjects excreted 7-11% (Av. 8%) of the test dose, and nine patients with B complex deficiencies excreted 0-1.5% (Av. 0.5%). These were free pyridoxine values; no work using total pyridoxine values has yet been reported.

The Neurospora method of Beadle (7) or the yeast method of Williams (8) might be used to determine normal blood levels and urinary excretion.

Rosenbaum (9) has developed a method for measuring muscular weakness quantitatively, and has attempted to relate it to pyridoxine status by determining muscular endurance before and after a dose of pyridoxine. However, this test needs to be standardized before it can be used clinically.

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PANTOTHENIC ACID STATUS IN HUMAN SUBJECTS
by Jean Peat

The methods of determination of p antothenic acid available for use in nutrition studies are microbiological. With these methods blood levels and urinary excretion can be measured.

The method using Lactobacillus Casei can be used for determining urinary excretion (1,2). Wright, in a study of medical students, has found that the 24 hour urinary excretion varies from 1.1-5.5 mg with a mean of 3.4 mg (3). This method is not adaptable for determining blood levels because the organism is stimulated by some substance in blood which is independent of either its riboflavin or its pantothenic acid content.

The method of Pelczar and Porter (4) using Proteus Morganii has been used for determining blood levels. The human blood pantothenic acid levels as determined by this method are 3-10 micrograms per 100 ml with an average value of 6.

Since all the above figures for urinary and blood panto-

thenic acid are on rather small groups of individuals, more work will have to be done before standards can be set up. Pantothenic acid is thought to be necessary for humans since Spies et al (5) and Siegel et al (6) have found a correlation between human blood values and certain B complex deficiencies.

There are no chemical tests for pantothenic acid. The chick test of Jukes (7) is not easily adaptable for human studies.

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VITAMIN K STATUS IN HUMAN SUBJECTS
by M. Winkelman

Since the chemical methods for determining K are not well enough developed, human deficiencies of K are detected by the prothrombin time test. Vitamin K is necessary for prothrombin formation, hence in K deficiency the prothrombin concentration in the blood is lowered and clotting is interfered with. However, K is not the only factor concerned in the production of prothrombin. Severe liver damage may cause low prothrombin levels and bleeding irrespective of available K.

A very few cases of K deficiency due to dietary lack have been reported, but these patients had either a diet completely free of fruits and vegetables for years or were alcoholic, but the occurence of K deficiency due to dietary lack alone is questionable. K deficiency probably occurs only in special groups - pregnant women, newborn infants, patients with liver and gall bladder disorders.

K deficiency tests are not used in nutritional status studies because

1. The test is not specific for K deficiency
2. A true dietary deficiency of K probably never occurs because the need for K is low and almost any mixed diet will supply this amount and K is probably formed in the intestinal tract by bacteria.

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PRESERVATION OF NUTRIENT VALUES OF FOOD DURING HOME PREPARATION

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Losses of nutrient value during food preparation are due mainly to the following:

1. Solution of water soluble mineral salts and vitamins in water which is thrown away. This means that not only the quantity of water in which a food is to be cooked should be scrutinized carefully but also that methods of washing and of cutting vegetables need attention. If wilted vegetables must be soaked before cooking provision should be made for use of the water. In most cases wrapping the vegetable in a damp cloth and storing in a cool place will serve to freshen the vegetable as well as soaking.

An exception to the rule of using pot liquor may need to be made in the case of the vegetables, such as spinach, which contain excessive amounts of soluble oxalates, but it must be remembered that desirable vitamins B_1 and C go out with the undesirable oxalic acid.

2. Oxidation and consequent loss of vitamins.

Ascorbic acid and vitamin A are most easily lost by oxidation. Unnecessary aeration of foods furnishing these vitamins is to be avoided. Procedures for serving and making purees need to be watched, since contact with copper catalyzes "C" destruction (see below). There may be some advantage in the use of cloth strainers.

Much oxidation may take place in the preliminary stages of vegetable cookery both because of increased enzyme activity and actual exposure to oxygen of the heated air. Hence it is desirable to cut vegetables directly into boiling water, salted to decrease solubility of oxygen. Maximum replacement of heated air by steam is always to be considered desirable. Hot air-steam mixtures are especially destructive as figures for excessive vitamin losses during high temperature braising and so-called "waterless" cookery indicate.

3. Enzymatic destruction of vitamins and that caused by other catalysts.

Several plant enzyme systems are capable of vitamin C destruction. This becomes more active when the plant cells are bruised or cut. Slow action of enzymes does, however, account for much loss of ascorbic acid in raw foods during storage. Citrus fruits and tomatoes show less loss of "C" on standing than do cabbage, kale and salad greens. Actually the "C" potency of some samples of fresh cabbage, steamed or put into boiling salted water have been shown to be higher than that of the same cabbage made into slaw and allowed to stand. Of course the "C" content of the cooked material has to be reckoned on that of solid material plus cooking liquid, since "C" is almost completely diffused on cooking.

For this reason steam blanching, i.e. wilting of fresh vegetables by several minutes exposure to streaming steam is advantageous in that it kills the enzymes without loss of vitamins by solution. It is important to remember that the chopped salad vegetables sold in celophane and the older wilted greens which have been on the market for several days have lost much potency.

Browning or dark discoloration of raw vegetables and fruits is an almost certain indication of ascorbic acid destruction. Preservation of the color of dried products by blanching with steam or hot salted water is associated with preservation of "C". This does not hold good for preservation of color with soda (see below).

Catalysis of the destruction of citamin C by traces of copper and possibly of other heavy metals must be borne in mind in dealing with diets which call for sieved or pureed foods.

4. The action of heat itself.

a. In connection with oxidation it is to be borne in mind that increases in temperature result in increased speed of oxidation. Apart from the effect of heat on oxidation, however, certain vitamins notably thiamin seem to be destroyed by heat. The rate of destruction rises sharply when temperatures are increased above the boiling point of water, as in pressure cookery. It must be recognized, however, that time of heating enters into the picture, and that heating for a long time at a moderate temperature, as in boiling, simmering or cooking in a double boiler is quite capable of producing the same result as heating for a short time in a pressure cooker.

The high temperatures reached in the outside layers of bread crust, roasted and broiled meats apparently cause considerable destruction of vitamins which are not usually classed as heat liable, e.g. riboflavin. In general, temperatures which produce browning or carmelization may be expected also to produce vitamin destruction, whether they are achieved in baking, roasting or frying, or "waterless" cooking.

b. The action of heat produces changes in protein which, in some cases at least, makes it less useful as material for building or repair in the body. Meat protein is so changed even at simmering temperatures, while milk and cereal problems show comparatively slight destruction during ordinary cooking periods at temperatures under 120°C, 248°F. As in the case of vitamins, it must be emphasized that not only temperature but also time of heating is important and prolonged heating even at simmering temperatures may be as destructive as short periods at higher temperatures.

The proteins of beans, peas and other dry legumes are notable exceptions to this rule. The action of cooking in softening fibers and increasing the absorbability of food stuffs is also to be considered. Not only is the biological value of

legume protein apparently increased by heat treatment but there seems also to be some evidence of better utilization of vitamin content.

5. The action of alkali.

Thiamin, several of the less well known factors in the B complex and ascorbic acid are unstable in the presence of dilute alkali, such as baking soda.

Cooking of vegetables with soda to conserve green color is an especially pernicious practice, since heat in the presence of alkali is capable of rapid elimination of vitamin activity.

There is some evidence which indicates that the use of soda as a leavening agent in quick breads results in large losses of thiamin, and possibly of other B factors. Use of indicators in biscuit dough leavened with baking powder shows uneven distribution of alkali with some areas in the danger range.

For the kitchen.

1. Prepare your vegetables as short a time as possible before cooking.
2. Shred or cut directly into boiling salted water, or place immediately in streaming steam, or seasoned, acid salad dressing. If food must be prepared ahead of time, store after blanching with steam or hot salted water.
3. Store washed vegetables wrapped in waxed paper - a damp cloth, or a tight container in the refrigerator to restore crispness. Don't soak in water to keep fresh. Rate of loss of vitamin decreases greatly at refrigeration temperatures.
4. Cook vegetables as short a time as possible to secure tenderness. Learn to like the textures of products cooked for a short time.
5. Use as small quantities of water as feasible in cooking vegetable.
6. Use the cooking water when it can be made palatable. Soup, gravies, sauces, may be improved by its addition.
7. Plan to make use of this water promptly and don't make a practice of adding hot cooking water to a non-sterile jar containing unused bits of left over cooking water two or three weeks old. This is excellent food for bacterial growth.
8. Don't add soda to vegetables while cooking. Preserve green color by placing in boiling salted water.
9. Use whole grain breads made with yeast where possible. Avoid leavening with soda.
10. Don't rely on white crackers, melba toast and prepared toasted breakfast cereals for B vitamins.
11. Cook only the amount of vegetables which you need for one meal. Much value is lost in stored and warmed over foods.
12. Use low temperatures in cooking meats - not only to conserve vitamins but also to prevent hardening and loss of biological value of protein to prevent shrinkage.

* Adapted from material prepared by Dr. Okey for the California State Dietetics Association.

FITTING YOUR DIET TO YOUR INCOME AND YOUR NEED FOR FOOD

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The problem of planning an adequate diet at a price we can afford to pay at a time of rapid increase in food costs, such as the present, calls for all the help which we can get from past experience. The Bureau of Home Economics and the Bureau of Labor Statistics made in 1935-36 rather widespread studies on foods purchased and used by families in various income groups in the United States. Most of the data from these are now available. On the University of California campus we have the Heller committee which has priced, once a year since 1923, budgets which are considered to represent all the necessary expenditures and most of the usual ones for four types of families - one in the "minimum health and efficiency" class, one for a "wage earner", i.e. with a breadwinner at at well paid mechanical work, one for a clerical worker, and one for a family of a better paid professional worker or executive. The food budgets for these families have been so adjusted that they have represented what has been, to the best of our knowledge, a nutritionally adequate supply of food for those families. Actual choice of items in the budget for the higher incomes has however, been the result of a compromise between what we have considered to be best choices and current custom. It is from my experience in working with these budgets that I seem best able to approach the present problem.

The four types of budgets chosen by the Heller Committee present somewhat different nutritional problems. The budget of the lowest income group is written for individuals, for the higher ones for families of four. For purposes of comparison we have added the four individual allowance of this "low cost adequate" budget. We presume that this family in the lowest income group will include a man at active physical work. His wife will likewise be active, hence have a rather high calorie requirement, i.e. be able to utilize foods with a high calorie to protein, mineral and vitamin ratio. The children are considered as a boy of 13 and a girl of 8 in all cases, hence, to be at a period of active growth. The same thing is true of the skilled wage earner's family, but income here is high enough to permit a more liberal food budget. The clerk's family with a sedentary breadwinner requires food with a lower calorie to vitamin and mineral ratio and a somewhat limited income makes it necessary to choose carefully the foods which are concentrated sources of protein, minerals and vitamins. In the case of the executive we have nutritional problems which are similar to those of the clerk but there is a more generous money allowance for foods. Since the ages of the children in all families are supposed to be the same and all budgets must provide adequate nutrients for activity and growth of these children, the family budget requirements as a whole are less different than they would otherwise be.

The total expenditures of the "executiv's" family came <u>in a normal year</u>, 1939-1941, within the \$6,700 -\$6,800 range, and <u>15%</u> was required for food. The white collar worker's budget came in the \$2,900 -\$3,000 range and about 24% was spent for food. The

wage earners budget came within the $2,300 range and 27% went for food. The low cost adequate or "dependency" budget for the family of four amounted in 1941 to between $1,225 -$1,250 and about 37% or $460 went for food.

These figures correspond rather well with those for relationship of food expenditures to total expenditures obtained in the United States Bureau of Labor Statistics and Bureau of Home Economics Consumption studies for families on similar income groups in 1935-36. We cannot disregard the fact that these consumption studies show that well over one third of the families in United States have incomes under our "health and efficiency" level. It must be remembered, however, that the data for these studies were collected from farm as well as urban communities and some of them from areas with food price levels very much lower than those of San Francisco.

The Heller food budget is probably open to criticism on the score that we assumed a too intelligent choice of foods. On the whole the nutritive values of the Heller budgets have compared very favorably with those given by Stiebling of the Bureau of Home Economics for food budgets at costs one level higher than ours. This has in large measure been made possible by the lower prices of fruits and vegetables in California. It has on the other hand been made more difficult by the higher prices of meats and of "staple" groceries and by certain fundamental differences between California food choices and those of eastern areas; for example, the small amounts of legumes consumed here.

From March 1, 1941 to March 1, 1942 the money required to purchase a year's food for the family of four at the "low cost adequate" level used by the Heller committee increased from $460 to $581, or 26.3%. Prices of fruits and vegetables increased about 39%, of cereals 3%, of meats 22% and of dairy products about 25%.

It seems therefore, that if we are to be able to recommend food choices, which will maintain health and morale in spite of extreme price fluctuation, the time has come for careful examination of the problems presented by the individual food groups.

I. DAIRY PRODUCTS:

Milk and milk solids. For the adolescent boy and girl in the upper income groups we recommend milk solids equivalent to one quart of fresh milk per day. In the lower income groups and in localities where fresh milk is expensive, we can substitute evaporated milk for fresh milk for all cooked dishes and cocoa with little or no loss in nutritive values. One tall can ($14\frac{1}{2}$ oz.) of evaporated milk is the equivalent of 3 1/2 cups of fresh milk. Since we use milk mainly for calcium, riboflavin and protein it is possible to substitute dried skim milk in the proportion of 3 1/2 oz. for a quart of fresh milk, or 5 level tablespoons for a cup of fresh milk. Fresh skim milk, where it is available carries everything but the fat and the vitamin A which we would get from whole milk. We can usually get these nutrients more cheaply from other sources. 3 1/2

oz. skim milk powder plus 1 oz. fat plus 2 oz. carrots equals 1 quart whole milk.

Cheese is an excellent milk substitute as a source of protein and calcium, in fact 4 1/3 oz. of ordinary American Cheese furnish as much protein as a quart of milk. Riboflavin and other water soluble vitamins are unfortunately partly lost in whey, nevertheless 3 1/2 oz. of cheese still furnishes about as much riboflavin as a cup of milk. For the family in the lowest income group we have substituted cheese for a fourth of the milk. Also we have included considerable quantities of cheese in a ll our food budgets, since it is not only a good source of calcium but also of protein of high biological value. Moreover, it is easily combined with macaroni, rice, eggs and vegetables to make meat substitutes.

Butter and cream furnish fat of high digestibility and are good sources of preformed vitamin A. However, there is little to choose between butter and many kinds of vegetable oils on the basis of digestibility or ease of utilization of fat. In fact many of the vegetable fats are richer sources of the "essential fatty acid", i.e. linoleic than is butter fat. Butter substitutes with 9000 international units of preformed vitamin A per pound are available at about half the price of butter. A fair average range of vitamin A content of butter is 9000 to 18000 units per pound. Additional A is to be had very inexpensively in the form of carrots, broccoli, dark green leafy vegetables. It seems desirable therefore, where food money is limited to spend it for milk and to use butter substitutes.

Eggs furnish an excellent, but expensive source of protein and riboflavin, iron and phosphorus. An average value per egg is 6 gm protein and 150 to 200 micrograms riboflavin. One ounce of beef liver furnishes almost as much protein, twice as much riboflavin and is an equally good source of minerals, vitamin A and of other members of the B complex. A glass of milk contains as much riboflavin and protein and 3 2/3 as many calories as one egg. Two slices of bread furnish roughly 6 grams of protein and a small serving of broccoli, mustard greens or spinach will if cooked to avoid waste by solution, furnish as much iron and riboflavin as one egg.

Practically we use eggs because they make for flexibility in our cooking and are an easily prepared and well liked protein concentrate, not because they are nutritionally indispensable. When the price of eggs is extremely high, it seems desirable to use fewer in the diet, when it is lowered we tend to use them in greater number. Usually the price of eggs has a greater seasonal fluctuation than that of other good sources of protein. It may be good nutritional economics to use more eggs in the spring, fewer in the fall. Three or four eggs per person per week allows for some preparation of cakes, puddings, cookies, etc. and furnish an adequate allowance for a low cost budget at all seasons. Where a more generous amount of money is available the number of eggs may be increased. Long continued use of more than one egg per adult per

day may be open to objection because of the high cholesterol content and the acidity of ash and richness in sulfur. Eggs, purchased in the spring and summer, dipped in some solution to prevent loss of water through the shell and stored, preferable at refrigerator temperature, or broken, mixed and frozen or dried, retain their nutritive value satisfactorily. Unfortunately it is difficult to buy frozen or dried eggs in small quantities.

II. MEAT:

The portion of the family food money spent for meat in America is usually much greater than the fifth which Sherman advises. In fact the tendency to spend unduly large sums for this item is so great that we are often tempted to conclude from studies of nutritional efficiency of diet in the low income ranges that adequacy is likely to be in inverse proportion to money spent for meat.

We must not lose sight, however, of the fact that meat furnishes protein of high biological value and digestibility and that this protein effectively supplements, as does the protein of eggs, milk and cheese, the cheaper proteins of cereals and legumes.

Intelligent buying of meat demands a knowledge of percentage of waste to be expected from different cuts. The buyer should also be familiar with the characteristics of meat from animals of different grades. On the Pacific coast she will receive little help from United States Government grade stamps, however, because the methods of feeding western cattle do not produce the fat distribution required to meet specifications for the high United States grades. A little experimentation on number of servings to be expected per pound of various cuts of meats carried in your local markets, on tenderness and on shrinkage to be expected from these cuts, and above all, on interesting methods for prepara tion, may be worth more, practically, than study of grade specifications. You will often find that purchase of cuts with a high percentage of waste such as short ribs of beef, breast of lamb, and, certainly of french chops and T bone steaks, gives you a much smaller number of pounds edible portion per dollar than purchase of such cuts as round of beef, sirloin butt, legof lamb, etc.

The higher iron and vitamin content of the organ meats, heart, kidney, and liver, especially, make their purchase desirable if the price is not extravagantly high, as it usually is for calves liver. Fish and shellfish are to be considered on somewhat the same basis, although pound per pound the protein content is usually about 10 per cent less than for muscle meat. We have considered that 1/4 lb. of meat per adult per day is a fair amount for the lowest cost "adequate" budget. For the family of four, this means 6 pounds of meat per week, which for the higher income groups has been increased to 10 lbs.

It should be understood finally that it is necessary in setting up a budget for pricing to list cuts which are most fre-

quently sold and for which representative prices can be secured in all markets and localities. The housewife will however, find it good buying practice to include some less frequently used meats, such as heart, tongue and organ meats in her list.

III. BREADS AND CEREALS:

Plain whole grained cereals such as oatmeal and whole grain flours have more to offer in the way of calories, protein and vitamins of the B group per unit cost than do any other group of foods, with the possible exception of the legumes. Hence, they are used to a large extent in diets where cost is a primary consideration. Most dry cereals and flours furnish very nearly 100 calories per ounce. This represents a moderate sized serving of cooked cereal. The protein contents of the cereals vary; 8% for rice, 8.5% for cornmeal, 10 to 13% for wheat products, depending on the method of milling, 16% for oatmeal. While the proteins of the cereals are, when used alone, not of high nutritive efficiency, mixtures of these proteins with those from meat and milk have high supplementary value. We may expect nearly as great nutritive efficiency from 100 gm of mixed milk and wheat protein as from the same amount of milk protein alone. Bread usually contains about 25-30% moisture, hence it is ordinarily safe to consider a pound of bread equal to between 11 and 12 ounces of dry cereal. One slice of bread 1/2 inch thick offers between 2 to 3 grams protein and 60-75 calories.

It is highly important in the low cost diet that the cereal used be whole grain cereal, which carries from 5 to 6 times as much thiamin per pound as does the highly milled product. There is moreover, some probability that the other B factors are in like proportion. Todate it has not been possible to obtain in synthetic form all the B factors which are furnished by the whole grain cereal. Hence, the "enriched" flours and breads cannot be regarded as equal to the natural product. Yeast leavened products are to be considered, from the angle of nutritive value, as better than quick breads, because of the destructive action of alkaline leavening agents on the B vitamins as well as because yeast is in itself a good source of the B factors.

IV. VEGETABLES:

This large and heterogenous group of foods has too often been considered in budgets without sufficient differentiation. In the past few years we have come to realize that each vegetable is an entity in itself. Morever, it is difficult to be sure that a diet in which we depend largely on vegetables for vitamins will be entirely adequate unless we can specify not only variety and amount to be purchased, but also something of grade, freshness, and, most important of all, method of preparation for the table.

On the other hand, many vegetables are available in rather limited seasons and sections of the country. Flavors tend to be pronounced. Hence, we encounter marked preferences and dislikes

among people of different racial backgrounds. No food budget can therefore be expected to be even reasonably satisfactory which does not allow considerable leeway for choice. An attempt at classification which takes into consideration mineral and vitamin as well as calorie contribution of vegetables has been included in The Proceedings of the 1941 Institute (page 72). We have worked out our budgets on the assumption that substitutions may be made within the groups indicated in this table, according to availability, cost and preference.

It is desirable when we write a budget for pricing standbyes to rely upon such as carrots, cabbage and potatoes which are almost always available and are universally known for their large contribution of nutrients per unit cost. But the housewife who is hunting the best values for her money cannot afford to overlook some of the more seasonally and sectionally available products. Broccoli for instance offers more ascorbic acid per pound edible portion than does cabbage, more vitamin A than carrots and is an excellent source of riboflavin and some of the other B factors besides.

Percentage of waste in the individual product purchased is a large factor in the determination of the desirability of any given vegetable. Variability in waste is so great in most vegetables that it may pay the housewife to go to market to inspect the product she buys. Loss of vitamin on transportation and storage is often considerable. This is a good argument for production of home gardens.

Finally, it may be said that even with the disproportionately great increase in the cost of vegetables in San Francisco, the less expensive ones remained, a s of March 1, 1942, the least cost sources of many vitamins and minerals.

V. LEGUMES:

Dried beans, peas, lentils and peanuts furnish almost twice as much protein per pound and nearly as much starch as do the cereals. Many of them are rich sources of vitamins of the B complex. Long cooking or pressure cooking is necessary to make this protein digestible. In general the low cost of production of the legumes gives them an important place in diets for restricted incomes. There is considerable difference in the efficiency of the legume proteins. Soy beans and peanuts have protein of higher quality than the others, and are at the same time good sources of fat and vitamins of the B complex. They are easily grown, hence assume great importance in wartime food supplies. In general legumes are more satisfactory constituents of the diet for the active than for the sedentary individual, because of their tendency to give rise to flatulence in the inactive person, Peanut butter on whole wheat bread with skim milk and dark green and yellow vegetables can be made into an adequate and inexpensive emergency diet.

VI. NUTS:

Nuts as a group are concentrated goods, rich in protein

and fat. Most of them are costly to produce. California walnuts and almonds and Texas pecans are most widely used of this group of foods. They furnish approximately 3000 calories per pound edible portion, with about 60% fat. Protein is of good quality. Vitamin content needs further investigation.

Peanuts are legumes, but they furnish about 25% protein and 40% fat, hence they are sometimes classed as nuts.

VII. FRUITS:

Fruits have usually been classified according to carbohydrate content. As such they fall into three groups. Bananas, figs, persimmons, have about 20% carbohydrate. Apples, peaches, grapes, plums, oranges, cherries, blackberries and similar fruits, from 10 to 15%, while strawberries and melons furnish well under 10%. Dried fruits vary from 66% carbohydrate for dried apples to 80% for raisins, with dates, figs, peaches and prunes at about 75%.

A more logical classification of fruits can be made on the basis of vitamin content. Citrus fruits furnish from 40 to 60 mg. of ascorbic acid per 100 gm edible portion. Strawberries, tomatoes and cantaloupe 25 to 50 mg per 100 gm. Apples, peaches, pears, plums 5 to 10 mg per 100 gm. Fresh apricots furnish 3000 to 8000 I.U. vitamin A per 100 gm, yellow peaches 1500 to 6000 I.U. per 100 gm, cantaloupe 400 to 2400 I.U. per 100 gm. Fruits with white or pinkish white flesh have little A. Commercially canned fruits retain a relatively high proportion of their A and C, but little B_1. The vitamin content of dried fruits is much more variable. If sulfuring is done at the beginning of the process and dehydration is carried on out of the sun A and C retention are high. Unfortunately we are not always able to tell from the a ppearance of a dried fruit the extent to which the vitamin has been preserved.

Canned fruit is graded according to strength of sugar syrup added, the appearance, ripeness, uniformity and flavor of the fruit. The higher and more costly grades must consist of relatively unbroken pieces of uniform size and color, in clear heavy syrup. Ripeness tends to make the pieces of fruit prone to break up. Hence, it is often possible to get better flavor in the medium grades. Descriptive labeling is as yet in its infancy.

In general the packing company puts its own label on the first or "fancy" grade of fruit. Labels for the second or "choice" brand are likely to remain uniform. The third or U. S. standard brand is often put out under a jobbers label or a label which varies from year to year, especially after a season in which the pack has not been entirely satisfactory. Most "fancy" fruits are marked packed "in heavy syrup", "choice", in "medium syrup" and"standard", in "light syrup". Certain odd packs, water packs for instance, can be made from fruit of any grade, and so labeled. Pie packs and fruits marked "below U. S. standard but fit for human food" are usually available only in #10 cans. The housewife will do well to investigate unadvertised brands, and to buy in quantity only after sampling.

VIII. FATS:

The use of fat always assumes special importance in wartime, both because it is expensive to produce and because war itself makes such a demand for fats, for purposes other than food.

Fat remains in the stomach longer than carbohydrate. Diets furnishing less than 100 gm of fat per 3000 calories are likely to prove unsatisfactory because they do not satisfy hunger for a long enough period. The use of rancid and semi-rancid fats is likely to lead to vitamin destruction. Apart from these two considerations choice of fat may be made on the basis of cost, availability and palatability with few further restrictions. Vegetable fats in general carry more vitamin E and less vitamin A than fats of animal origin. Partially hydrogenated fats have better keeping qualities than those not so treated. Fats of melting point at or somewhat below body temperature are most readily emulsified and consequently most easily digested.

IX. SUGARS AND SWEETS:

Can sugar is, in normal times one of the cheapest sources of calories. The tendency is to use too much of it for good nutrition, since it supplies nothing but calories. Problems of the wartime sugar ration arise partly because of its high satiety value, i.e. ability to satisfy appetite; partly because of its use in preserving fruits. Substitutes are:

1. Honey. This is about one and one half times as sweet as cane sugar. Good quality honey is a most prohibitively expensive, and produced in relatively small quantities. It usually has a very distinctive flavor apart from its sweetness. The sugar is largely invert, i.e. a mixture of equal parts of glucose and fructose.

2. Corn syrup. This consists of a mixture of the products of hydrolysis of corn starch, dextrin, maltose and glucose and is not very sweet. Further hydrolysis by boiling with a small amount of some fruit acid increases sweetness and adapts it to some extent for use in preservation of fruit. The dark varieties have a higher mineral content and a more distinctive flavor than the light.

3. Dextrose. Dextrose, glucose, "cerelose" or corn sugar is sweeter than corn syrup, less so than cane sugar. So far, it can be purchased only in wholesale lots. Possible war requirements for corn sugars, syrups and molasses make it problematical how far it is desirable to work out methods for substituting these for cane sugar. We do, however, have tremendous reserves of the raw material from which they are made.

4. Fresh and dried fruits. When the cost allowance makes it possible dried fruits with a sugar content of from 75 to 80% are a very satisfactory substitute for cane sugar. Raisins at 8¢ per

per pound furnish four fifths of a pound of sugar and a considerable amount of iron besides. Dried peaches and apricots furnish 3/4 lb. of sugar per lb. fruit and have a high vitamin A content as well. Fresh orange juice often contains as much as 10% dextrose, and is an excellent source of vitamin C. Increase in the amount of fresh and dried fruit is a logical substitution for cane sugar.

5. Starch, flour, cereals supply carbohydrate calories equally as well as sugar. When combined with smaller amounts of fresh, canned and dried fruits they make very satisfactory dessert substitutes for sugar.

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These suggestions refer to courses for those without previous instruction in the subject and should not be confused with the procedure for Refresher Courses which are designed for those who have had previous instruction of college grade in nutrition and its foundation sciences.

Henry C. Sherman, Professor of Nutrition, Columbia University, has said, "There is ample objective evidence that food habits can be improved by education in nutrition and food values, even with the purchasing power of the people as low as it is now ---------. Each of us who can do anything for nutrition education should do it at once and continually and with confidence in its value ------".

Who may take the Nutrition Course?

Homemakers, especially those with children, upon whom the facts of war have impressed the importance of human nutrition.

Prospective nutrition aides for the local nutrition program for defense.

Members of the food committee of the Red Cross Chapter.

Prospective Canteen Workers for the Red Cross Chapter.

Other community groups of men and women.

A Statement of General Objectives for the Nutrition Course.

1. To develop an understanding and appreciation of the dependence of the human body upon food, i.e. how the body utilizes food for growth and health and the probable effects in physical fitness and efficiency, of inadequate diet.

2. To create the desire to improve one's own and one's family nutrition through an intelligent application of food facts to menu planning, food selection, buying and cookery.

3. To encourage the development of good personal and family food habits.

4. To develop an understanding of the influence of such factors as income, racial customs and habit, good dislikes, kind of equipment for food preparation and the availability of foods upon family practices of food selection and preparation.

5. To create in students an awareness of their own problems of nutrition (if any) and to find some approaches to their solution.

Methods of Teaching.

It is good pedagogy in presenting scientific information either to give the practical application first, and through it and similar illustrations, interpret the facts and principles or to give the facts and principles and immediately apply them.

Example: give students an immediately usable and interesting outlet for the scientific information they get; such as, after naming cabbage, peppers and tomatoes as good sources of Vitamin C, suggest a recipe for cole slaw with a sour milk or cream and cheese dressing for a salad.

The majority of homemakers are without scientific background sufficient to untangle phrases and concepts. They are more interested in interpreting their practical daily experiences as meal planning and cooking in light of the newer knowledge of nutrition. Terminology should therefore be simplified as much as possible and emphasis be upon the significant application of nutrition facts, rather than the research techniques or scientific facts per se.

Use every available kind of visual aids:

1. Pictures selected from Forecast and current magazines.
2. Slides and films from the Department of Agriculture, Washington, D. C. and the University of California, Department of Visual Instruction and elsewhere.
3. Advertisements; labels from cans and packages.
4. Food models from University of Chicago, Dr. Lydia Roberts, Department of Home Economics $1.00) or the California Dairy Council, 216 Pine Street, San Francisco, ($1.00).
5. Actual foods in the markets.
6. Photographs (projected on an opaque projector) drawn from current literature and text books in foods and nutrition.
7. Charts and posters.
8. Experimental animals if they can be procured from nearby laboratories or visited.

Stress the fact throughout the course, that nutrition is a rapidly developing subject, with new facts being continually discovered. That to keep up to date, it is necessary to read reliable material (not commercial advertisement) and consistently check on one's own habits and practices.

Make the teaching personal and informal; gain the confidence of your students; talk with them rather than down "at" them. Through their reports of meals eaten, through their questions and suggested problems, know them individually. Sometimes a check list or questionnaire given at an early date, will give insight into personal habits, problems and facts with which the teacher can work more effectively.

Points to be considered in presenting nutrition material to lay course

1. At all times keep within the bounds of normal nutrition.

The reducing diet cannot be considered in the realm of normal nutrition. Aside from pointing out the high and low caloric foods and stressing the point that all diets, reducing or otherwise must be adequate in protein, minerals and vitamins we can go no further because

a. it is not a simple thing to work out an adequate reducing diet taking into account the individuals food preferences, economic status and customs,
b. it is impossible (and illegal) for us to judge whether a certain obesity is a simple over indulgence in food or complicated by an endocrine unbalance,
c. we should stress the idea that no one should diagnose or treat himself, but should consult a physician who can outline and supervise a reducing regime and should discourage the indiscriminate use of the reducing diet which encourages quacks.

2. All scientific information must be presented in a simple manner and directed toward practical aspects. The constituents of an adequate diet should ordinarily not be taught in terms of grams, protein, I. U., vitamins, etc., but in terms of foods or food groups to include in the diet for each day. If these foods cannot be purchased or the family will not eat them, teach what can be substituted in approximately what quantities.

3. The economic aspects of food choice must always be kept in mind. Good sources of essential food constituents should be compared as to cost, and this consideration will also show up seasonal variations.

4. Any material distributed to the lay class must be

a. limited in amount so as not to cause confusion,
b. simple and practical in form so as to be easily understood and used,
c. as accurate and unbiased as possible.

Such material is available from the Office of Defense Health and Welfare Services in Washington, D.C., and through state and county nutrition committees.

5. The group should be reminded that the final goal and aim of the class is not only to improve the nutrition of their own families but also to help promote better nutrition for their community and country as a whole. This may be done by taking an interest in

a. School lunch programs,
b. requesting properly labeled and graded foods,
c. creating a demand for more healthful, less refined flour and cereal products,
d. buying food wisely and preparing it carefully in order to eliminate waste,
e. learning of kinds and quantities of foods which furnish equivalent nutrients and which may need to be substituted one for the other as scarcities develop or foods need to be released for the armed forces,
f. growing home gardens where this is practical,

g. intelligent home and community food preservation.

Topics which should be covered in an Elementary Nutrition Course.

These topics do not each call for a full two hour lesson. Some may be covered in shorter time, for others you may need nearly three hours. Make your outlines for the nine lessons and plan accordingly.

1. General dietary standards in American homes and what is needed for improvement of these standards.
2. The energy need.
3. Need for protein.
4. Need for minerals.
5. Need for vitamins
6. Food groups and the part they play in good nutrition.
7. New ideas for food preparation and cooking.
8. Keys to economy; buying, storage, cooking, seasonal variation, equivalents and low cost foods.
9. Planning a well balanced diet; 24 hour requirement.
10. Review.

Suggested Class Procedure.

1. Introduction.
2. Presentation of subject matter.
3. General discussion.
4. Brief summary.
5. Discussion of the subject for the next lesson and assignments of problems and reading.
6. In a two-hour course divide subject matter so that there is an opportunity for one or two short intermissions. Exhibits and posters can be studied at this time.

Outlines of two lessons.

It has been recommended that Refresher Courses especially those held as Seminar Groups, work out detailed outlines for lectures to lay groups as part of one meeting of the seminar. The authors feel that any detailed outline given here would result in uninspired repetition of someone else's ideas. The lessons attached are samples of two types of lecture notes by two different teachers of lay courses, to give you an idea of how to organize material, not as outlines to follow.

BODY REGULATION

I. General

A. What is a vitamin?
1. Complex compound in food in most minute quantities essential to certain body functions.
2. Vitamins are formed by green plants and taken into the human body by food.

3. Vitamins are not "killed" but many are changed by heat and exposure to air so that they no longer act in the body as important essentials for body health.

B. Why we are concerned about amount of vitamin rich foods we eat.
   1. Discuss wide margin between passable and buoyant health.

C. Can we get too much of a vitamin
   1. Not if we get our vitamins from foods in varied diet.

D. Can we get all vitamins we need by taking certain vitamin pills? Present knowledge says no.
   1. Large intakes of certain vitamins (as taking in concentrated form seem to increase requirement for others)
   2. Discuss the rapid advance in knowledge of B complex. Commercial vitamins probably lack some not yet analized.

E. How do we know about these vitamins?
   1. From history we had hints of their existance.
      a. Limies of the British Navy
      b. Discovery that lack of sunshine and incident of rickets were correlated.
      c. Early use of liver (Egypt 1500 B. C.) to improve eye sight in dim light.
   2. From feeding experiments on animals we have learned the results of law vitamin intake and the vitamin content of various foods.
   3. By certain tests for vitamins in the blood and urine of humans we can study the human requirements for the vitamins.
   4. Information on human needs and reactions to vitamins-natural or synthetic - is still speculative. We need to read new authentic publications on this subject.

II. Specific

A. Fat soluble vitamins
   1. Vitamin A
      a. Forms
         (1) Carotene (plant sources) which animals turn into vitamin A
         (2) Vitamin A preformed (animal sources)
      b. Sources
         (1) Best animal sources
             Fish liver oils, liver, whole milk, cream, butter
         (2) Best plant sources
             Green leafy vegetables, as escercle, yellow fruits and vegetables as apricots and carrots.
      c. Functions
         (1) Necessary for normal growth
         (2) Necessary to keep mucous membrane healthy
             (a) <u>Not</u> anti-infective except as keeps mucous membrane of nose and throat healthy giving germs less chance to cross membrane and enter body.

(3) Necessary for normal dentition
(4) Necessary for seeing quickly and easily in dim light (or at twilight) as when entering a theatre or coming into dark room out of the sun.
(a) Important for air pilots.

d. Stability
(1) Fairly uneffected by heat if no air or oxygen present
(2) Readily destroyed by oxygen even by exposure to air at room temperature.
(3) Not destroyed by drying of fruit if sulphured

e. Storage
(1) Stored in large amounts for a long time in the liver

2. Vitamin D
a. Sources
(1) Best animal sources, fish liver oils, irradiated milk
(2) Best plant sources, none to be recommended
(3) Most direct source - sunshine - irradiation of your own skin when practical

b. Functions
(1) Necessary for best absorption and use of Ca and P in bone and teeth formation

c. Stability
(1) Quite stable

d. Storage
(1) Good over long period

B. Water Soluble vitamins
1. Vitamin B_1 - Thiamin
a. Sources
(1) Best animal sources - fresh pork muscle (Must be well cooked even then good source)
(2) Best plant sources
(a) Whole grains (endosperm and outer coating) and products.
(b) Dried legumes

b. Functions
(1) Prevents beriberi (which involves nervous system)
(2) Necessary for normal growth
(3) Helps maintain appetite
(a) Will not improve appetite if lack of appetite is not due to low thiamin intake
(4) Necessary for full use (burning) of carbohydrate foods
(a) Increased C H O intake increases B_1 requirement

c. Stability
(1) Destroyed by heat with or without oxygen
(2) More stable to heating in dry state than in solution

(3) More stable in mod. acid than alkalin
(4) During drying less destruction if not sulphured

d. Storage
(1) No appreciable storage

2. Riboflavin
a. Sources
(1) Best animal sources, meat, especially glandular, milk and eggs
(2) Best plant sources, green leaves and growing tips, broccoli and kale

b. Functions
(1) Necessary for some life processes of tissues
(2) Aids body in maintaining defense power against disease
(3) Seems to prevent the early onset of ageing

c. Stability
(1) quite stable

d. Storage
(1) Fair storage

3. Nicotinic acid(niacin)
a. Sources
(1) Best animal sources meat, lean meat, especially liver, eggs
(2) Best plant sources greens, kale, mustard, turnip

b. Functions
(1) prevents pellagra
(a) nervous disorders
(b) dry scaly skin
(c) inflamed tongue
(d) severe digestive disorders

c. Stability
(1) Insufficient study to draw conclusion

d. Storage
(1) Again insufficient study

4. Vitamin C - Ascorbic acid
a. Sources
(1) Best animal sources, none of practical importance
(2) Best plant sources are citrus fruits, tomatoes, cabbage, potatoes, and turnips

b. Functions
(1) Prevents scurvy
(a) Bleeding gums and sore joints (only if due to C deficiency)

c. Stability
(1) Fairly stable to heat
(a) If no oxygen present
(b) If in acid solution
(2) Readily destroyed by oxygen even by exposure to air at room temperature
(a) less destruction if slightly acid as in citrus fruit juices

(3) Not destroyed by drying of fruit if sulphured
(4) Destroyed by drying of fruit if it is not sulphured

d. Storage
(1) Relation of time of storage to loss of nutrition value in
(a) fresh foods
(b) canned and dried products
(c) refrigeration

III. Special needs for vitamins
A. The requirement for all vitamins is greatly increased during
1. Pregnancy
2. Lactation
3. Periods of rapid growth
a. infancy
b. adolescence

KEYS TO ECONOMY

I. Review
A. Value of foods to supply growth, health
B. What needs must especially be watched
(Ca., Fe., vitamins C, A, B_1, B_2, etc.)
C. Family needs for special ages and activities

II. How to buy wisely
A. Cost studies
Reference: Supplement to Proceedings, Heller Studies for 1942
B. How much of income should be used for food
C. How should the food budget be divided
1. Discuss number of children and their needs
2. Sherman suggests five groups
a. Milk, cheese, ice cream
b. Meat, fish and eggs
c. Fruit and vegetables
d. Bread and cereals
e. Fats and sugars
3. Or spend as much for milk as you do for fruits and vegetables or meat
D. Discuss the itemized Heller food budget which most nearly reaches the average of your class
E. Check with individual food lists kept by the class for the previous week and brought into study at this time

III. Substitutes
A. Low cost foods
1. How high cost protein may be supplemented by use of cheese, legumes, canned meat. Economical meat buys - discuss use of trimmings for soup, amount bone you pay for, etc.
2. Butter and substitutes food value
3. Fresh milk or canned
4. Canned or dried vegetables for fresh
5. Fruits and vegetables in season
6. Discuss quality statements on labels of canned goods

B. Study table of food values to make substitutes for family special needs or tastes, also cost ofequivalent charts in Supplement to Proceedings.

IV. Care of food after purchase
   A. Use of outer leaves, etc.
   B. How to wash and store without waste
   C. Buy staples in bulk or large sizes, discuss when wise
   D. Vegetables and fruits buy as fresh as possible (Not the cut or chopped variety)
   E. Cooking and serving
      1. Waste results if not seasoned and served well
      2. Cheap cuts of meat-give extra flavor, need for care in preparation
      3. Recipes
      4. Use of vegetable water for soups and gravy
      5. Variety, balance, color (do not use tomatoe salad and tomatoe as a vegetable atsame meal)

Suggestions for source material.

I. For teachers
   1. Sherman, H. C. and Lanford, C. S. Essentials of Nutrition, The MacMillan Co., 1940
   2. Proceedings of the California Defense Nutrition Institute and Supplement, The California Nutrition Committee; University of California, Berkeley
   3. Proceeding of the National Conference for Defense, Washington, D. C., 1941, Order from Supt., Documents. Washington, D. C., In press. (Price not given)
   4. Bogert, L. Jean; Nutrition and Physical Fitness, 1939
   5. Bogert, L. J. and Porter, N.T.: Dietetics Simplified, 1940
   6. Youmans, John: Nutritional Deficiencies, 1941
   7. The Vitamins - pub. by Amer. Med. Assoc. 1938 - new series to be published during 1942
   8. McCollum, Orent, Keiles & Day - Newer Knowledge of Nutrition, The MacMillan Co., 1939, 5th ed.
   9. Sherman, H. C.: Chemistry of Food and Nutrition, The MacMillan Co., 1941, 6th ed.
   10. The Art and Science of Nutrition (written for nurses) Hawley and Carden, C. V. Mosley, 1941
   11. Evaporated Milk Association, 307 North Michigan Ave., Chicago, Ill. Excellent material
   12. Nutritional Charts - H. J. Heinz Company, Mr. R. L. Shaw, Sales Dept., 1266, 14th Street, Oakland, California, Free

II. For students
   1. Human Nutrition - Reprint of Part 1 of the Yearbook of Agric. for 1939. Yearbook separate No. 1668 U. S. Dept. Agric. for sale: Supt. of Documents, Washington, D. C. 40¢ (stamps not accepted for material purchased from Supt. of Documents.)
   2. Are We Well Fed? Hazel K. Stiebeling, U. S. Dept. of Agri., Misc. Pub. No. 430, 1941. Order from Supt. Documents, Washington, D. C., 15¢

3. Hidden Hungers in a Land of Plenty - A Handbook of Nutrition Projects for you and your group. National Maternal and Child Health Council, 1710 Eye Street, N. W. Washington, D. C., Price 25¢
4. The Kitchen Course in Nutrition - Safeway Homemakers' Bureau, Price 25¢, Box 660 C. C., Oakland, California
5. Publications from:
   U. S. Dept. Labor, Children's Bureau, Washington,D.C.
   U. S. Dept. Agri., Bureau of Home Economics, Washington, D. C.
   Write to Supt. of Documents for reference list of material available.
6. Sherman, H. C. and Lanford, C. S. Essential of Nutrition, 1940, The MacMillan Co., $3.50
7. Rose, Mrs. Mary D., Feeding the Family, 4th ed., 1940 The MacMillan Co., $3.75
8. The Art and Sciences of Nutrition (written for nurses) Hawley and Carden, C. V. Mosley, 1941
9. Several large food companies have excellent material available which is free for the asking. Samples would be available for the classes to see, but each person should write for his own copy
10. Nutrition service, American Red Cross, Food & Nutrition